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ORIGINAL ARTICLES.

I.—Note on the Discovery of *Miolania* and of *Glossotherium* (*Neomylodon*) in Patagonia.

By Francesco P. Moreno, F.R.G.S., Corr.M.Z.S.Lond.,
Director of the La Plata Museum.

SINCE 1877, when I discovered the Tertiary Mammalian beds of Santa Cruz, in Patagonia, I have been looking for proofs of the ancient connection between the new uplifted lands of the southern part of the American continent and the other lands of the Southern Hemisphere—Africa and Australia. During my subsequent travels in the interior of the Argentine Republic, including Patagonia, my interest in that connection has been increasing, and I have discovered additional evidence, which showed me the former greater extension to the east, in comparatively modern times, of the actual existing lands. The splendid results of the researches made by the La Plata Museum in Patagonia have revealed a great number of lower forms of vertebrates, including numerous marsupialia, some of which seem to me closely related to the mammals of the Pleistocene fauna of Australia, and among them *Pyrotherium* with *Diprotodon*. I think that my suggestion has an indubitable confirmation in the discovery made by the expeditions which I sent in 1897 and in the first months of this year, under the direction of Mr. Santiago Roth, expeditions that have had astonishing results.

In beds containing remains of mammals and dinosaurians, Mr. Roth discovered in 1897 a caudal sheath-ring, very similar to those of the *Glyptodon*, but which I at once recognized as pertaining to a form like the chelonian of the Pleistocene of Queensland, described by Owen. I brought this fossil with me to London for comparison with the remains of *Miolania* preserved in the British Museum (Natural History). The resemblance was great, but the fact of a Tertiary chelonian from Patagonia being analogous to the Pleistocene genus from Queensland and Lord Howe Island was so astonishing, that some doubt was permitted; but, having previously ordered a new examination of the fossiliferous bed where the remains were found, I have now the certainty of the extremely close relation between the Australian and Patagonian chelonian. I have received

several photographs of a skull discovered by Mr. Roth, which photographs, when compared with the Australian specimens in the British Museum (Natural History), give no place for doubt upon this matter. I think that it is sufficient for the present to give two

B A

Fig. 1.—Front view of skull (A) and side view of tail-sheath (B) of *Miolania Owenii* (greatly reduced), from Pleistocene Deposits, Queensland, Australia.
[Originally described as *Megalania prisca* (Owen, 1880).]

cuts representing the two forms of *Miolania*. I expect in a few days the original specimen from Patagonia, together with various bones and additional remains of the caudal sheath, with some of the carapace. These will be the subject of a special description by Mr. Arthur Smith Woodward, who has so kindly commenced studies on the fossil reptiles in the La Plata Museum.

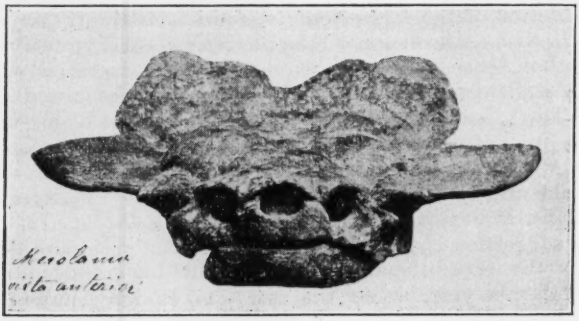


Fig. 2.—Reproduction of photograph of the front view of skull (with the lower jaw) of *Miolania*, obtained in 1899 from Patagonia by Mr. Santiago Roth, of the La Plata Museum, Argentina. (Greatly reduced in size.)

I have also brought with me to London a piece of a skin discovered in a cave near Last Hope Inlet (lat. S. 51° 30′), which I have referred to a species of the extinct *Mylodon* (see, "On a Portion of Mammalian Skin, named *Neomylodon listai*, from a Cavern near Consuelo Cove, Last Hope Inlet, Patagonia," by Dr. F. P. Moreno, C.M.Z.S.; with a description of the specimen by A. Smith Woodward, F.Z.S.); while Mr. Ameghino has announced that another piece of the same skin pertains to a mammal still living, of small size, which he has called *Neomylodon*. When I took this piece at Last Hope Inlet in

November, 1898, I was convinced that it was part of the skin of a *Mylodon* or a form very similar to it, and that the discovery was of great importance to me, as I think that the Pampean muds, where the extinct Edentata are found, are of very modern age, an opinion contrary to that held by another observer, Mr. Ameghino, who refers the Pampean fauna to the Tertiary age. I have already maintained that the extinction of the greater part of the Pampean fauna took place after the presence of man in a relatively advanced culture, called Neolithic culture. Having, then, great interest in the continuation of the investigations in the cave, I ordered, before coming to London, more extensive researches, and these have been made with very successful results.

Dr. Otto Nordenskjöld had previously obtained in 1896 a piece of the same skin, which, it is known, was discovered by a party of Argentine surveyors during the preliminary studies for the boundary between Argentina and Chili in the Andean Cordillera, and, recognizing also the importance of it, Dr. Erland Nordenskjöld went last year to the same spot to look for some more remains. The excavations which he made gave him, so far as I know, some bones, pieces of jaws, teeth, and claws of the same animal, but he did not obtain more remains of the skin.[1] My assistant, Mr. Hauthal, arrived later at the cave, when Dr. Erland Nordenskjöld had terminated his researches, and commenced further exploration. He obtained, not only skulls, jaws, teeth, bones, and claws, but also a nearly complete skin of the animal, which shows that it is a *Glossotherium*, together with bones of *Macrauchenia*, *Equus*, and *Auchenia*, also a great quantity of dung, hay cut by man, ashes, and some bones worked by man. I am not yet sure if the bones of man discovered by Mr. Hauthal were found in the same cave or in one of those in its neighbourhood; but the presence in the *Glossotherium* deposit of bones worked by man is a proof that man and other mammals, whose remains have been discovered in the cave, were contemporary. I suggest that the skin has been preserved by man for bedding. In the caves inhabited by ancient man in Patagonia I have seen cut hay, and probably this also was used for beds.

I expect to receive in a few days all these specimens at the same time as those of the *Miolania*, together with reports on the discoveries, and I think they will arrive in time for me to exhibit these remains at the meeting of the British Association at Dover.

The discovery made by Mr. Roth of some advanced Mammalia in the beds that contain dinosaurians, and Mr. Hauthal's discovery of remains of extinct vertebrates and other mammals in the caves of Southern Patagonia, associated with *Macrauchenia*, horse, *Auchenia*, and man, are proofs of the very recent changes in the physical geography of Patagonia, and afford most interesting problems, which can only be solved by a systematic examination of the Argentine country by experienced geologists. In the course of my paper read before the Royal Geographical Society, I proposed that this Society,

[1] E. Nordenskjöld, "Neue Untersuchungen über *Neomylodon listai*": Zool. Anzeiger, vol. xxii (1899), pp. 335, 336.

the Royal Society, and the British Museum, with other scientific institutions, should proceed to carry out these necessary investigations. These problems are not extraneous to the explorations which may be carried out by an Antarctic expedition, and I think the new discoveries which I now communicate to the GEOLOGICAL MAGAZINE may urge on the dispatch of such expeditions as I propose. If these expeditions be made, how many changes may be produced in actual and general ideas on the age of the South American fossiliferous strata, on the disappearance of the lost southern lands, and on the affinities of extinct faunas so distant in time and space as those of South America and Australia.

II.—CONTRIBUTIONS TO FOSSIL CRUSTACEA.

By Professor T. RUPERT JONES, F.R.S., F.G.S., and HENRY WOODWARD, LL.D., F.R.S., F.G.S.

(PLATE XV.)

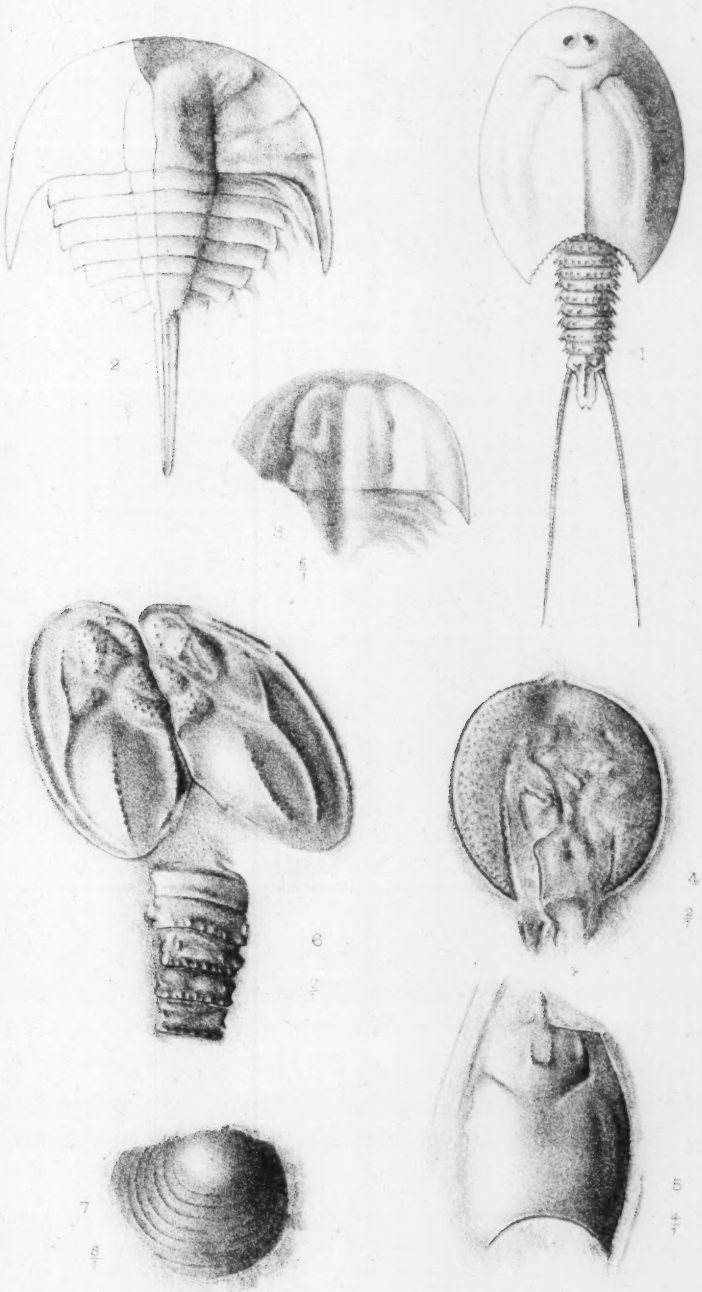
THE following notes are devoted to a small series of Crustacea, not directly related to one another, but which have been awaiting a favourable moment for description.

1. BELLINURUS GRANDÆVUS, Jones & Woodw. (Pl. XV, Figs. 2 and 3; × 6 diam.)

Through the kindness of our friend Dr. Henry M. Ami, M.A., F.G.S., Assistant-Palæontologist to the Geological Survey of Canada, and with the permission of the Director, Dr. G. M. Dawson, C.M.G., F.R.S., we received, a year ago, two tiny specimens of Palæozoic Limuloid Crustaceans, referable to the genus *Bellinurus* of König. Dr. Ami writes:—"The precise locality of these protolimuloid Crustaceans is the 6th cutting east of Riversdale Station on the Intercolonial Railway of Canada, in the county of Colchester, Nova Scotia. There are besides this Crustacean (which you are at liberty to describe if you wish) a number of plant- and animal-remains associated in the same beds, viz.: *Asterophyllites acicularis*; *Sphenopteris*, sp.; *Cyclopteris* (*Aneimites*), sp.; Ostracoda; *Anthracomya obtenta*, etc., etc. A species of *Leaia*, closely related to *Leaia tricarinata*, also occurs here, and fern-pinnules allied to *Neuropteris*, besides *Calamites*, *Cordaites*, etc. The shales from which these Crustaceans were obtained are overlain conformably by sandstones and red shales of great thickness, and these in turn are unconformably capped by Lower Carboniferous Marine Limestones. Thus, in descending order the strata are:—

1. Lower Carboniferous Marine Limestones.
   (Unconformity.)
2. Red rocks of Union and Riversdale Series.
3. Black, grey, and glossy shales of Riversdale and vicinity.
   (Unconformity.)"

1. Turning to the specimens themselves, the label states "the first specimen found by Mr. Ami" (which is represented on Pl. XV, Fig. 3, enlarged six diam.) is said to be from the "3rd cutting



G.M. Woodward ad nat. lith. West, Newman imp.

1. Recent, 2-7. Fossil Crustacea.

east of Colnary River (30, vi, 1897)," and shows a nearly entire head-shield and a portion of five thoracic segments of a small Limuloid Crustacean, probably near to *Bellinurus reginæ*, Baily, from the Irish Coal-measures, and measuring in its present imperfect state 5 mm. in breadth and 4 mm. in length. The cephalic buckler is twice as broad as it is long; the angles of the shield are moderately produced, and the ocular and median ridges of the shield are very distinctly marked, and also the position of the compound eyes; the thoracic segments are distinct, and sharply pointed at their free extremities. The margin of the head-shield is slightly thickened and raised, and the front margin somewhat depressed. The telson or tail-spine is not preserved. Each specimen is *intaglio*.

2. The second specimen obtained ("6, vii, 1897") is labelled from the "*Asterophyllites* or 6th cutting east of Riversdale, Colchester Co., Nova Scotia." Although only one side of the specimen and the telson are preserved, it happens to take in rather more than one-half, so that by tracing and reversing the outline one obtains a very correct idea of the form of the entire animal (Pl. XV, Fig. 2). The specimen is larger than No. 1, measuring 9 mm. in length and 7 mm. in greatest breadth when restored. The artist did not detect the ocular line in this specimen, but it is really present as a minute depressed line outside the glabella, having a deeper spot where the compound eye was situated. Three radiating lines seen on the right side of the head-shield are probably traces indicating the presence of some of the six pairs of maxillipeds or jaw-feet seen in the modern King-crab (*Limulus*). The cheek-spines of the head-shield are well developed, and extend backwards to the 4th thoracic segment. Five well-defined thoracic segments can be distinctly observed, and two (or three?) shorter abdominal ones in front of the telson. The lateral margins or pleuræ of these thoracico-abdominal segments appear to be distinctly truncated, unless, as is just possible, their pointed extremities may have been detached and have adhered to the counterpart impression of the specimen which has not been preserved. The median axis of these segments rapidly diminishes in breadth from the head towards the telson, as is seen to be the case in *Bellinurus reginæ*. The telson or tail-spine is robust, and rather more than one-third of the entire length of the animal.

As stated elsewhere—see Pal. Soc. Mon., "Brit. Foss. Crustacea: The Merostomata," Part V (Xiphosura), 1878, p. 236—we believe that the five segments composing the thorax in *Bellinurus* were free and moveable, as in the larval stages of the young of the living *Limulus polyphemus* and *L. Moluccanus*, and that such was also the case in *Neolimulus falcatus*, H. Woodw., from the Upper Silurian, Lesmahagow, Lanarkshire, the earliest Limuloid Crustacean that we know.

Although *Bellinurus* is a very ancient type of *Limulus*, it has not at present been found in rocks of earlier age than the Coal-measures, nor can we assert that the black, grey, and glossy shales of Riversdale, Colchester Co., Nova Scotia, in which these specimens occur, are older than Carboniferous.

Leaia Leidyi, T. R. Jones, which occurs with *Bellinurus* in these Riversdale black shales, occurs in the Lower Carboniferous of Pennsylvania, but in rocks "regarded by some geologists as the uppermost part of the Devonian or Old Red Sandstone."[1] *Leaia* also occurs in the Upper Coal-measures of Lancashire and the Lower Carboniferous of Fifeshire (Jones, op. cit.).

In his "Acadian Geology" (3rd edition, 1878), Sir William Dawson gives an interesting account of the geology of Colchester Co., Nova Scotia, and figures *Leaia Leidyi* (misspelt '*Leidii*') from the Lower Carboniferous Coal Formation (see p. 256, fig. 78*e*). At p. 258 he also gives a section at Walton which would seem to justify the inclusion of the Red Rocks of Union and Riversdale in the Lower Carboniferous Series, thus uniting these disturbed beds in one group. But this suggestion is made with the utmost diffidence, in the absence of a knowledge of the district.

As the two specimens of *Bellinurus* (Pl. XV, Figs. 2 and 3) are both imperfect, and better materials may at any time be forthcoming, it seems prudent to refrain from suggesting more than one trivial name. This Crustacean may therefore be known as *Bellinurus grandævus*, Jones & Woodw., Lower Carboniferous Series, Riversdale, Colchester Co., Nova Scotia.

2. Hibbertia orbicularis, gen. et sp. nov. (Pl. XV, Fig. 4.)

This small Crustacean shield, together with other specimens, was presented to the British Museum, many years ago, by our late friend Dr. John Millar, F.G.S., of Bethnal House, Bethnal Green. The specimen is imbedded in a finely laminated, micaceous, non-calcareous shale (bluish-grey in section), and bears the label "Coal M., Burdiehouse." It was at first believed to be one of Dr. Hibbert's types from Burdiehouse, but nothing like this fossil was found to have been figured or mentioned in Dr. Hibbert's memoir[2] on the strata and fossils of Burdiehouse; therefore, its occurrence there, as shown by its old label, is of great interest. It was reserved for description with other Phyllopods to form part of a monograph in course of publication by the Palæontographical Society; but upon further examination it was found to differ so markedly from the other members of this division that it was held over for some time for further consideration and comparison. It has now become necessary to give it a name, and place it approximately among its congeners.

Specific Characters.—A nearly circular shield, 14 mm. broad by 15 mm. long, having an opening behind, bounded by two acute incurved angular spines which form the backward extremities of the concentric shield or buckler-like test. The periphery of the concentric part of the test is turned up sharply as a thin rim in the fossil, leaving a uniform narrow groove behind it, from which the field of the buckler rises with a gentle swelling over and along the

[1] "Fossil Estheriæ": Pal. Soc. Mon., 1862, p. 117, pl. v, figs. 11, 12.

[2] See Dr. S. Hibbert's memoir, Trans. Roy. Soc. Edinburgh, vol. xiii (1836), p. 280, plates.

crescentic area, except where the edge falls in for a little space just on the centre of the front border; where the buckler becomes slightly depressed and the narrow groove along the margin is interrupted or perhaps injured there is an obscure impression of what may have been a jointed antennary organ in front. The surface of the two lateral areas of the buckler have a finely granulated ornamentation, which is most marked just within the peripheral rim of the carapace, and is limited by two thin parallel granulated ridges, each starting from the incurved posterior angles of the shield, the longest being 7 mm. and the shortest only 4 mm. in length; the intervening space of 5 mm. in breadth, forming the centre of the carapace, is devoid of the granulated ornament seen on the other parts of the shield, and has only a small spine-like impression 3 mm. long, which extends for three-quarters of the entire length of the shield as a curved irregular incised line. There are some other markings, too obscure for interpretation; also a slight posterior projection on the central line, as if possibly representing a part of a lost series of caudal segments (?).

The presence of the two corresponding angles, and the narrow posterior opening between them, suggests affinities with *Dithyrocaris* (cf. *D. Scouleri* as represented by McCoy, with its two raised lateral ridges), but in most of the members of this group the lateral portions of the shield are less circular in outline, and in many the surface ornamentation is composed of linear or reticulate, and only occasionally of granulate markings. Compared with the shield of *Apus* or *Lepidurus*,[1] the general outline is much alike, but the granulated mesolateral ridges continued forward from each of the posterior angles in *Hibbertia* are not present in *Apus*, whereas the median ridge so conspicuous in both *Apus* and *Dithyrocaris* is apparently quite absent in *Hibbertia*, or is not preserved in the fossil. Contrasted with the anterior (cephalic) buckler in *Limulus*, the shield of *Hibbertia* is seen to be nearly circular, whilst that of *Limulus* is semicircular; the posterior angles of the shield of *Hibbertia* are contracted together and directed somewhat inwards at their extremities, whilst in *Limulus* they are wide apart and directed rather outwards. The mesolateral (ocular) ridges are present both in *Hibbertia* and *Limulus*, but in *Limulus* they form a curved line, not a straight ridge as in *Hibbertia*.

The granulation on the lateral areas of the shield and on the ridges is also strange to *Apus*, and more closely resembles that seen in some species of the Carboniferous genus *Cyclus* (cf. *Cyclus Johnsoni*, H. Woodw.,[2] and *C. testudo*, Peach, the former from the Coal-measures of Coseley, near Dudley, the latter from the Carboniferous shales—so rich in Crustacea, Arachnida, etc.—of Eskdale on the Scottish borders).[3]

[1] See Plate XV, Fig. 1, copied from Dr. A. S. Packard's figure. (Mon. Phyllopod Crustacea of North America, 1883, pl. xvi, fig. 1.)

[2] See "Contributions to our Knowledge of the Genus *Cyclus* from the Carboniferous Formation of various British Localities," by H. Woodward: GEOL. MAG., Dec. IV, Vol. I (1894), pp. 530–9, Pl. XV.

[3] Trans. Roy. Soc. Edinburgh, vol. xxx (1883), p. 227, pl. xxviii, figs. 9–9*d*.

None of the earlier fossil forms of Limuloid Crustaceans hitherto figured and described (examples of two of which, Figs. 2 and 3, are given on Pl. XV with *Hibbertia*, and of which a series may be studied on pl. xxxi, figs. 1–8, Pal. Soc. Mon. Merostomata, part v, 1878) aid us in finding a suitable form for comparison with the shield of *Hibbertia*, nor do the larval stages of the recent *Limulus* greatly assist us in this direction (see op. cit., pl. xxxiii). We are therefore reduced to the conclusion that *Hibbertia* may be more conveniently placed along with and near to those forms referred to the genus *Cyclus* than with any other group. Under these circumstances we prefer to regard it as being characteristic of a distinct genus, and we name it after Dr. Hibbert, with whose discoveries in the Carboniferous strata at Burdiehouse it is most closely associated.

From the paper by H. Woodward, already referred to, we make the following extract, to show the conclusions arrived at by the writer as to the affinities of the curious little forms included in the genus *Cyclus*, to which family, under the name of *Hibbertia*, our specimen from Burdiehouse must now be added.

"The presence of antennæ and biramous swimming-legs proves undoubtedly that *Cyclus* was a Crustacean. The large size of the former and the homogeneous nature of the rest of the appendages (all biramous swimming-legs, with possibly masticatory bases), taken in connection with the large, slightly-bivalved carapace, suggest that it is an Entomostracan and probably one of the Phyllopoda, with a broad cephalic carapace like that possessed by *Apus* and by *Daphnia*; with large swimming second antennæ like the latter, and possibly with a pair of stalked eyes. *Cyclus*, however, differs from the Cladocera in being flattened dorso-ventrally, and from the lowest Crustacea in not apparently possessing any true jaw-parts—the head, with the labrum and mouth, being bent further back than in the living Entomostraca. These differences may either indicate very lowly characters or very much specialized ones. Two views suggest themselves:—

"(1) That these animals were small, free-swimming Phyllopods, with expanded cephalic shield, swimming second antennæ, and biramous limbs, the bases of which served as masticatory organs, no true jaws having yet been developed; the backward position of the mouth may have been brought about in order to allow as many appendages as possible to serve as jaws, as is seen in *Limulus*. Or, possibly, the beast could attach itself, like a living *Daphnia*, by a cement gland on the dorsal side of the head, in which case it might be an advantage to have the mouth as near the freer end as possible and close to the swimming-legs, which were, by their movements, producing the foot-currents.

"(2) The other view is that these animals were ecto-parasitic Phyllopods, although they had not lost their power of free-movement, yet had become specialized in the form of their body, which is flattened ventrally and only slightly convex above, the whole animal being expanded horizontally, unlike most other

Phyllopods. This view might account for the two large round structures seen on the ventral surface, situated one on either side of the body, and close to the anterior margin of the shell. These might possibly represent a pair of ventral suckers, such as are seen in the modern fish-lice; these structures, whatever they may be, are evidently enormously developed, and possess great muscles, which produce prominent modifications of the dorsal shield, where they are attached. The great labrum might possibly represent the suctorial tube of *Argulus*, under cover of which are concealed the reduced mandibles, etc.

"Some of the specimens show curious oblique scars on the coxæ of the legs, which may indicate the points of attachment of spines or setæ to enable the parasite to stick to its fishy host." (Geol. Mag., 1894, pp. 534–5.)

3. Anthrapalæmon glaber, Jones & Woodw. (Pl. XV, Fig. 5.)

This small cephalothoracic shield of a Macrouran Decapod Crustacean was obligingly sent to us by our friend and correspondent, Mr. John Smith, of Monkredding, Kilwinning, who obtained it in the Coal-measure series of Kilmaurs, Ayrshire. The other specimens which accompanied this will be dealt with elsewhere. The specimen, which is 7 mm. long and 5 mm. in breadth, displays a gently rounded, almost smooth carapace, preserved on a fragment of fawn-coloured shale enclosing plant-remains. The carapace has no dorsal ridge, but there is a well-marked cervical furrow forming an open V-shaped depression across the carapace in the centre; a small but prominent rostrum is seen in front, and the cervical furrow gives rise to a gastric furrow and spine on either side, only one of which, however, that on the right side, is preserved. The sides of the carapace are slightly expanded and smoothly arched, and there is a faint trace of a serrated border on the hepatic region, terminating in a short anteriorly directed spine. The posterior border is deeply and roundly emarginated, and has a thickened, raised, and smooth rim. The surface of the test is smooth, and quite free from ornamentation. The specimen closely resembles *Anthrapalæmon Etheridgei*, figured and described by Mr. B. N. Peach, F.R.S., from Eskdale (see Trans. Roy. Soc. Edinb., 1883, vol. xxx, figs. 4 and 5), but may be specifically separated from it by its absence of ornamentation; it may bear the trivial name of *A. glaber*.

Locality.—Coal-measures: Kilmaurs, Ayrshire.

4. Echinocaris Whidbornei, Jones & Woodw. (Pl. XV, Fig. 6.)

The following note on *Echinocaris* has been most obligingly sent to us, together with the three specimens, by Mr. A. K. Coomára-Swámy, the discoverer of the beautiful specimen drawn on Pl. XV, Fig. 6:—

"This phyllopod was first described and figured in the Geol. Mag., Dec. III, Vol. VI (1889), p. 385, Pl. XI, Fig. 1, by Professor Rupert Jones and Dr. H. Woodward, from a specimen found by Mr. Dufton in a quarry at Sloly, near Barnstaple, in beds of the Baggy or Marwood series, associated with *Lingula squamiformis* and other

fossils. There is also a fragmentary specimen in the Porter collection, from Pilton, near Barnstaple. Mr. Dufton's specimen was redescribed and refigured by the Rev. G. F. Whidborne in the 'Monogr. Devonian Fauna of the S. of England' (Pal. Soc., vol. iii, pt. 1, 1896, p. 6, pl. i, fig. 3). In 1896 I was in the Sloly quarry with the Geologists' Association, and found a small slab bearing one good specimen [Pl. XV, Fig. 6] and a cast of another. Later, the same day, the corresponding half was found by Mrs. A. M. Davies. These specimens are referred to in the Proc. Geol. Assoc., vol. xiv, pt. 10, p. 440, and in the Brit. Assoc. Report of the Committee on Paleozoic Phyllopoda, 1897. In my specimen the valves are slightly elongated and narrowed by shearing, but are nevertheless equal in breadth to those of the first specimen. Five body-segments are visible. They bear the tubercles characteristic of *Echinocaris* on their posterior margins. The other specimen, occurring as an impression on the same slab, is smaller; three body-segments are seen in Mrs. Davies' half. Two other specimens have since been found by Miss Partridge, of Barnstaple, in the same locality."

By the kindness of Mr. A. K. Coomára-Swámy we have been allowed to study his own specimen, and also the two obtained by Miss E. M. Partridge, of Barnstaple. One of Miss Partridge's specimens (732) shows evidence of the body-segments behind the carapace; both valves are present, but rather squeezed out of shape. The other specimen (759), although the valves are less perfect behind, shows the anterior border with the granulated surface of the valves very beautifully, and what appear to be two ocular spots (or tubercles) near the anterior border. We are much indebted to Miss Partridge and also to Mr. A. K. Coomára-Swámy for the opportunity to see and examine these rare Devonian Phyllopods.

5. Estheriina extuberata, sp. nov. (Pl. XV, Fig. 7.)

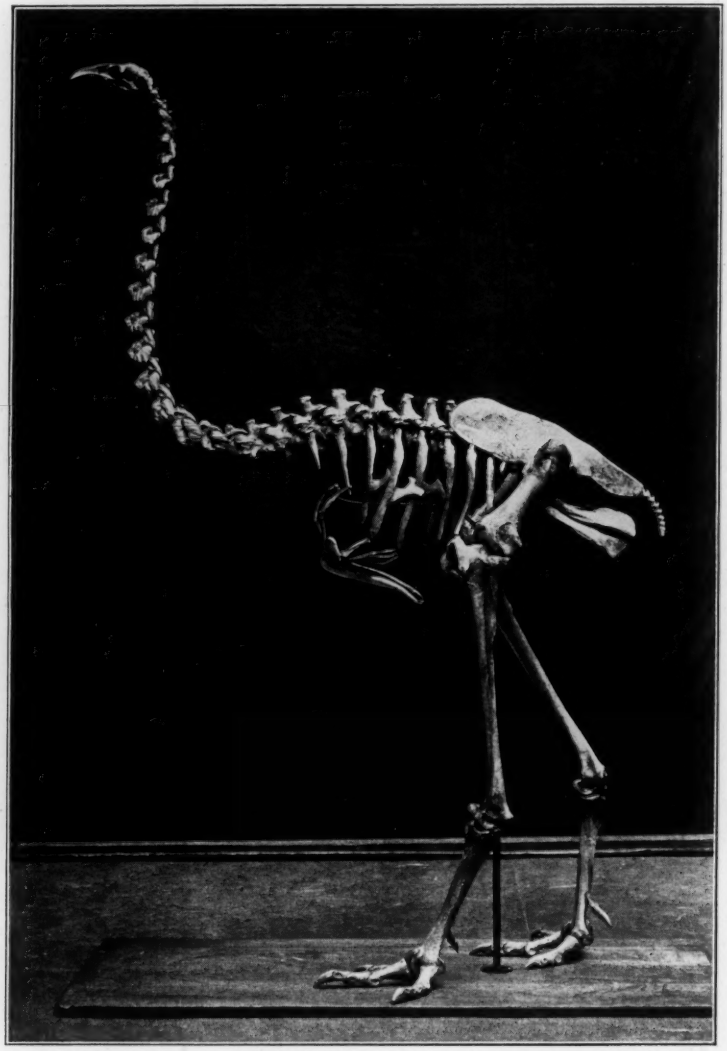
This seems to be the very tumid umbonal portion of a right-hand valve of an *Estheriina*, separate from the rest of the valve. The flat marginal portion of the valve may have been broken away, or perhaps lies hidden in the matrix.

Size.—Length 3 mm., height $2\frac{1}{2}$ mm.

The valve is semicircular on the ventral and nearly straight on the dorsal border; but the swollen umbo bulges out to some extent at the anterior third of that hinge-line. It slopes gently down to a rather blunt angle in front, and with a short hollow slope to a sharp angle behind.

The umbo is large, convex, very smooth, and shiny, $1\frac{1}{2}$ mm. broad, 1 mm. distant from the anterior and scarcely $\frac{1}{2}$ mm. from the posterior angle. It extends downwards for 1 mm. nearly to the middle of the valve, and is succeeded by seven concentric, broad, undulatory ridges, each having a raised line, mostly $\frac{1}{4}$ mm. apart, with smooth interspaces.

The strong local convexity of the valve, succeeded by a limited series of coarse concentric riblets, reminds us of the similar feature



Dinornis maximus, Owen.

Specimen discovered by Mr. C. A. Ewen at Invercargill, South Island, New Zealand.

Height as mounted, 8 ft. 6 in.

in *Estheriina* (Geol. Mag., May, 1897, pp. 198, etc., Pl. VIII, Figs. 1–11); but there is wanting the flat outer extension of the valve along its free margins. It may be a separate umbonal boss, such as occurred with the Brazilian specimens, and one of them also was described as being shiny (loc. cit.).

Indeed, the specimen under notice much resembles the very distinct umbonal area of *Estheriina astartoides* (as represented in Pl. VIII, Fig. 7, Geol. Mag., 1897), with its six or seven coarse riblets and their smooth interstitial spaces; the umbo itself, however, is relatively much larger in the German specimen. The Brazilian fossil, from a cutting on the railway 83 kilometres from Bahia, was in a shale of Cretaceous age. The Stegocephalian limestone from which Baron von Reinach obtained the specimen here described is of Permian age.

This little fossil was communicated to us for description by Professor Fried. Kinkelin, of the Senckenberg Museum, Frankfurt-on-the-Maine. It was found by Baron A. von Reinach[1] in the Stegocephalen-Kalk near that city.

EXPLANATION OF PLATE XV.

Fig. 1. — *Lepidurus glacialis* (after Dr. A. S. Packard). (Mon. Phyllopod Crustacea, North America, 1883, pl. xvi, fig. 1.) Recent: North America.

,, 2. } *Bellinurus grandævus*, Jones & Woodw. Lower Carboniferous Series:
,, 3. } Riversdale, Colchester Co., Nova Scotia. × 6 times nat. size.

,, 4.—*Hibbertia orbicularis*, Jones & Woodw. Coal-measures: Burdiehouse, near Edinburgh. × twice nat. size.

,, 5.—*Anthrapalæmon glaber*, Jones & Woodw. Coal-measures: Kilmaurs, Ayrshire. × 4 times nat. size.

,, 6.—*Echinocaris Whidbornei*, Jones & Woodw. Marwood Beds (Devonian): Sloly, near Barnstaple, Devon. × twice nat. size.

,, 7.—*Estheriina extuberata*, sp. nov. Permian: Frankfurt-on-the-Maine. × 8 times nat. size.

III.—Note on a nearly complete Skeleton of *Dinornis maximus*.

By Chas. W. Andrews, B.Sc., F.G.S., British Museum (Nat. Hist.).

(PLATE XVIII.)

An exceedingly well-preserved and nearly complete skeleton of the largest species of *Dinornis*, *D. maximus*, has recently been mounted and exhibited in the Palæontological Galleries of the British Museum (Natural History). The finding of this fine specimen has been described by its fortunate discoverer, Mr. C. A. Ewen,[2] and to his paper a brief account of the remains themselves was added by Captain Hutton.[3] It appears that the bones were found on shifting

[1] Baron von Reinach has communicated to us other Phyllopods from the Permian of the Wetterau and the valley of the Nahe; see Rep. Brit. Assoc. for 1893 (1894), pp. 465–6, pl. i, figs. 1–5.

[2] "On the Discovery of Moa-remains on Riverton Beach": Trans. New Zealand Institute, vol. xxviii (1895), p. 651.

[3] Tom. cit., p. 652.

sand-dunes about a mile from the sea in the neighbourhood of Invercargill (South Island). The bones had been buried under several feet of sand which had been removed by the wind, exposing a portion of the pelvis, the remainder being still buried in wet sand. The skull was found in remarkably perfect condition, and some 200 ossified tracheal rings were collected. A few days previously another skeleton had been discovered under similar circumstances, and it is probable that from time to time others may be exposed.

Some two feet below the skeleton, Mr. Ewen came upon rotten flax-sticks and a bed of water-worn shingle, and he considers that probably these marked the position of the bed of an old watercourse down which the carcases of the birds drowned by floods were washed.

The two skeletons thus brought to light differ from one another in some important particulars. Thus, in the specimen now figured it is stated that the basi-occipital is deeper, the maxillary processes much less developed, the paroccipital processes do not extend so far back, the temporal fossæ are deeper and broader, the basisphenoidal region is longer and the premaxillæ shorter and considerably narrower than in the skull of the other specimen. Moreover, with this latter only seven tracheal rings were found, while with the present specimen there were about two hundred. Professor Hutton has made some interesting remarks (*loc. cit. supra*) as to the probable nature of these differences. He points out that they may be (1) sexual, (2) specific, (3) merely the result of individual variation, and for several reasons comes to the conclusion that they are sexual, the skeleton of the male being that now figured, the other of the female.

The most important reasons for this conclusion are, firstly, that in the case of the last-mentioned specimen a great number of fragments of egg-shell were found among the bones, in such a position as to render it highly probable that the egg was inside the bird at the time of its death; and secondly, the tracheal rings in the same individual were incompletely ossified. The skull is remarkably well preserved. It shows the flattening and deflection of the broad blunt premaxillary region, the marked inclination forward of the occipital plane, and the other characters enumerated by Professor T. J. Parker as characteristic of the genus *Dinornis*.[1] The tracheal rings are elongate-oval in outline, the long axis being 32 mm., the short 14 mm.; and since almost all are of exactly the same shape, there can be no doubt that they have not been distorted by pressure or otherwise. The width of the band of bone of which they are composed varies from about 5 mm. opposite the ends of the long axis to 4 mm. opposite the short.

Some of the measurements[2] of the skull are given below.

[1] "On the Cranial Osteology, Classification, and Phylogeny of the Dinornithidæ": Trans. Zool. Soc., vol. xiii (1895), pp. 417, 418.

[2] Measurements taken according to the rules laid down by Professor T. J. Parker in the paper above referred to.

	mm.
Length of skull	227
Length of *basis cranii*	47
Width at paroccipital processes	93
,, temporal fossæ	69
,, squamosal prominences	107
,, postorbital processes	133
Distance between temporal ridges	42
Greatest length of premaxilla	144
Width of body of premaxilla	72
Width of lower end of quadrate	40
Length of mandibular ramus	209
Greatest depth of mandibular ramus	25
Length of symphysis	31

In the skeleton as mounted there are only twenty true cervical vertebræ, and of these the fifth and seventh have been restored in plaster. The atlas is abnormal, there being no bony bridges over the vertebral arteries. There is a large median hæmapophysis on the last cervical and on the four succeeding vertebræ, and a trace of it on the fifth. The neural spine of the last cervical, like those of the vertebræ behind it, is not bifid. There are two or three cervico-dorsals and three or four free dorsals; of the cervico-dorsals the second has been restored. The presence of only twenty cervicals instead of twenty-one may be accounted for by the probable loss of one of the anterior cervicals.

The sternum of this specimen was unfortunately broken into many fragments, but has been, as far as possible, mended and restored in plaster. Although many pieces were missing, its general outline is probably as nearly as possible correct, and it is interesting to note that it differs in several respects from the sternum referred to this species by Owen ("Extinct Birds of New Zealand," pp. 415–16, pl. xcviii), being relatively narrower, and having less divergent postero-lateral processes and an unbifurcated xiphisternum; the last-mentioned feature, however, is not quite certain, this region being very imperfect. There are facets for the articulation of two pairs of ribs. Both coraco-scapulæ are preserved.

The pelvis, which was in a very good state of preservation, presents no important peculiarity.

The bones of the hind limbs are perfect with the exception of the hind toes, of which only one claw is preserved, and the inner toe of the right foot.

Some measurements of this specimen are given below :—

	ft.	in.
Total height as mounted	8	6
Height to top of pelvis	5	7
Length of femur	1	3¾
Length of tibio-tarsus	2	7½
Length of tarso-metatarsus	1	7
Width of distal end of tarso-metatarsus ...	0	6¾
Length of middle toe	0	11

IV.—The Silurian and Ordovician Rocks exposed on the Shore near Balbriggan, County Dublin.

By Charles Irving Gardiner, M.A., F.G.S., Cheltenham College.

BALBRIGGAN is a village in County Dublin, some nineteen miles north of Dublin, and along the coast in its neighbourhood Ordovician and Silurian[1] rocks are exposed for a distance of about five miles. These are described in the Irish Survey Memoirs,[2] but from a recent investigation of the locality it seems desirable to give a fresh account of its geology.

The rocks exposed seven miles to the south, at Portraine, have been recently examined and found to be, in the main, of Middle or Upper Bala age,[3] while some unfossiliferous grits were doubtfully assigned to the Silurian period, owing to their similarity to the grits occurring at Balbriggan amongst which it was announced that several species of *Monograptus* had been found.

The river Delvin runs into the sea about two miles north of Balbriggan, and it is on the south side of its estuary that, coming from the north, one first meets with Palæozoic rocks, after the long strip of coast occupied by Quaternary deposits south of Drogheda. The beds exposed near the Delvin are green grit, and slates dipping S.S.W., and are the lowest beds observed along the coast. Near Lowther Lodge black slates are seen, and a good deal of intrusive diabase and two small dykes of kersantite are noticeable. Sections from this latter rock show well-formed bleached micas with much decomposed felspars. Quartz, calcite, and chlorite have been met with as secondary minerals, while a good deal of apatite occurs.

Opposite the Cardy Rocks, olive-brown slates occur, much veined with diabase intrusions, and in these slates *Leptæna sericea* was found, while the Survey Memoir gives the following fossils as coming from these beds:—[4]

Favosites fibrosa.
Calymene brevicapitata.
Cybele verrucosa.
Leptæna sericea.
Orthis Actoniæ.
Orthis calligramma.
Orthis porcata.
Strophomena alternata.
Strophomena deltoidea.

These fossils mark the beds as being of Bala age.

The beds now curve round so as to dip S.E., and after a small fault a few bands of brown slates are seen and a garnetiferous ash, and then for nearly two miles the shore is occupied by a series of igneous rocks. These are, in the main, andesites, sections of the rocks showing much decomposed plagioclase felspars in a groundmass chiefly made up of secondary chlorite and calcite, with numerous small felspar microlites. Amygdales are fairly common, and are generally composed of calcite and chlorite.

[1] The term Silurian is used in this paper to include rocks from the Llandovery Beds to the Ludlow Beds.
[2] Memoir to accompany Sheet 92 (1871), Geol. Surv. Ireland.
[3] Q.J.G.S., vol. iii (1897).
[4] Memoir to accompany Sheet 92, p. 21, Geol. Surv. Ireland (1871).

ERRATUM.

P. 323, 4th paragraph, 3rd line: for "we have *not* got," read "we have *now* got."

Amongst these lavas several bands of ashes were found, one of them fairly coarse, but the bulk of them fine in texture. Two intrusions of a somewhat coarse diabase were also noted.

The dip of the ash beds was, wherever visible, to the S.S.E., but its angle could not be determined with accuracy. The coarse ash can be seen in a hand-specimen to include fragments of extremely amygdaloidal lava, and the microscope shows that in the finer rocks these originally pumiceous fragments were also entombed.[1]

Just south of Balbriggan the cliffs are made of Drift, but at the next headland beyond the village igneous rocks are again found; these are still andesitic, and are covered by fine grey-green ashes, with, on one horizon, a layer of large included fragments of a fine purple ash.

About 340 feet of brown slates are then seen dipping at about 55° S.S.W., and then comes a thin band of black slate containing *Monograptus*, sp. ?[2] showing that we have not got above beds of Bala age; but the specimens did not permit of their specific characters being found, so that the horizon was not determinable.

Another small dyke of kersantite is seen in these brown slates, and they are soon covered by grits. Close by here are the black slates mentioned in the Q.J.G.S., 1897, p. 531, as having yielded:

Monograptus Becki (Barr.).
,, *spinigerus* (?) (Nich.).
,, *Halli* (?) (Barr.).
,, *triangulatus* (Harkn.).
,, *Hisingeri* (Carr).
Monograptus fœculum (Lapw.).
,, *lobiferus* (?) (McCoy).
Diplograptus tamariscus (Nich.).
Petalograptus palmeus (Barr.).

From this fossil evidence it seems probable that these slates are at the top of the *M. gregarius* zone of the Middle Birkhill.

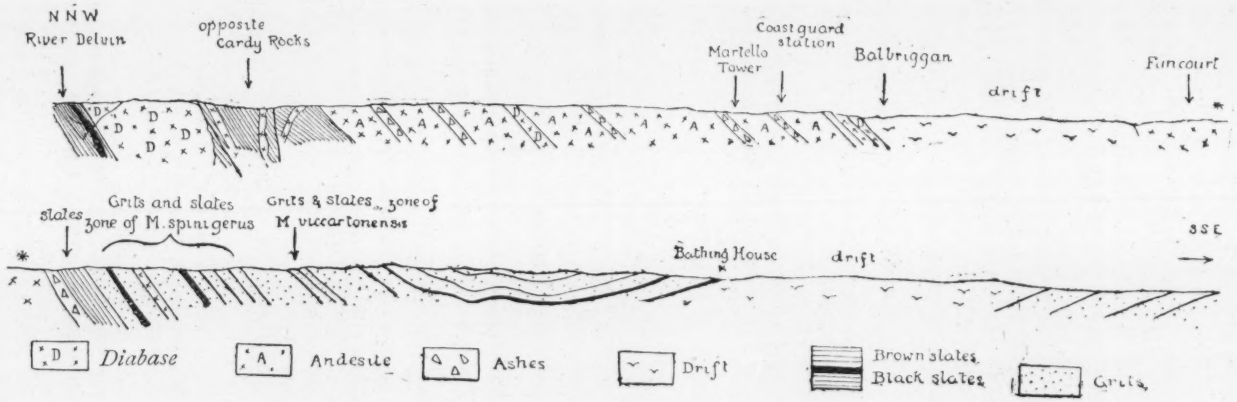
The next graptolitic black slates are about 500 feet above the lowest one noted above, and has yielded obscure species of *Monograptus*, but 10 feet higher comes a band with *M. spinigerus* (Nich.) and *M. priodon*? (Bronn), while 70 feet above this band is one with *M. spinigerus* (Nich.), *M. Hisingeri* (Carr), and *M. Galœensis* (Lapw.), and 80 feet higher still a band yielding *M. Hisingeri*? (Carr). These fossils seem to show that the bands which they characterize are in the *M. spinigerus* zone of the Upper Birkhills.

A slight change in the direction of the dip is now seen, the beds being still fine grits with layers of black slates at intervals, and their dip being 35° S.S.E. The next graptolitic layer, 85 feet above the last one mentioned, contains a species which appears to be *M. Riccartonensis* (Lapw.), and the same fossil occurs in two bands a little higher up in the series.

About 1,200 feet of rock occur above the highest of these three bands, chiefly made of grey grits, with here and there black slates, and then the beds begin to curve up in the opposite direction and

[1] See Geikie's "Ancient Volcanoes of Great Britain," vol. i, p. 244.

[2] All the graptolites mentioned in this paper have been examined for me by Miss Elles, of Newnham College, Cambridge, and my best thanks are due to her for her extreme kindness in so doing.



Section along the Coast near Balbriggan, Co. Dublin, Ireland.

(Length of Section, 4 miles: Scale, 13 inches to the mile.)

dip to the N.N.W. At the axis of this syncline the beds roll slightly and small dislocations have occurred, and then for about half a mile to the south-east one sees a repetition of the succession one has already passed over while coming from Balbriggan. Unfortunately, just where the graptolitic slates should be exposed, the Palæozoic rocks are obscured from view by a thick capping of drift, and when next Primary rocks are seen they are the grey grits occurring below the graptolitic slates, and from this point the shore-line follows the strike of the beds all the way to the village of Skerries. Near this place are three islands showing gritty beds dipping south-east at 30° and higher, while ash beds are seen as well, corresponding no doubt to the ash beds between the igneous series and the grits to the south of Balbriggan.

Thus the geological evidence of this strip of coast shows that after the Middle Bala period, when the Cardy Rock slates were laid down, there came a great outpouring of andesitic lavas with occasional scatterings of ashes on the igneous rocks. Subsequently the lavas were covered by ashes, on which grits and slates were deposited. These last rocks are shown by their fossils to be of Silurian age, and the equivalents of the zones of *Monograptus gregarius* (Lapw.) and *M. spinigerus* (Nich.) in the Birkhill shales; while higher still come graptolitic bands which, if their fossil evidence be correctly determined, must represent a much higher horizon and are the equivalents of the Wenlock beds.

Unfortunately, the specimens are very poorly preserved, and Miss Elles states that they "resemble very closely *M. Riccartonensis*." This species, she advises me, is usually found in a definite horizon above the *Cyrtograptus Murchisoni* zone (which is at the base of the Wenlock Beds), or else in the highest part of that zone. Consequently, if this specific determination be correct, we have between the highest fossiliferous band of the *M. spinigerus* zone of the Llandoveries 85 feet of rock before we come to the first fossiliferous band of the Wenlocks.

In County Down somewhat similar graptolitic shales have been described by Swanston.[1] There the zone of *M. spinigerus* is covered by the Portaferry Beds, with *M. Riccartonensis*.

The thickness of the beds in the Balbriggan section is not easy to determine, but the following approximate numbers have been arrived at:—

Wenlock-Llandovery Beds	2,300 feet shown.
Igneous series.	
Bala sedimentaries	1,700 feet shown.

What the date of the diabase and other intrusions was there is no evidence to enable one to find out.

Further south at Portraine the igneous series of andesitic lavas was overlain by calcareous rocks of Middle Bala age, so that from the two areas we may conclude that there was a great outflow of andesitic rocks in this part of Ireland in Middle Bala times. There

[1] Report of the Belfast Field Club, 1876-7.

is nothing in this area approaching the coarse tuffs and breccias of Lambay Island, and the coarse porphyry so well seen on that island and occurring also at Portraine is not to be seen near Balbriggan.

It is obvious that as we go away from Lambay Island we are getting away from the great centre of eruption, and though the explosive outbursts did carry ashes as far as Balbriggan, yet it was not very frequently that they did so. It is also worthy of remark that no trace of calcareous rocks are to be seen in the Balbriggan area. The conditions requisite for the formation of such rocks obtained during Middle Bala times both at Lambay and at Portraine, but near Balbriggan shales and shales alone are the result of sedimentary deposition during that period.

V.—On some Pliocene and Post-Pliocene Shells from Egypt.

By R. Bullen Newton, F.G.S.

(PLATES XIX AND XX.)

THE following notes have been drawn up from a small series of shells belonging to the late Tertiary and Post-Tertiary formations of Egypt, which form part of a collection of fossils sent home for determination by Captain Lyons, R.E., Director-General of the Geological Survey of Egypt.

The principal literature on this subject has been furnished by Leith Adams,[1] S. P. Woodward,[2] Oscar Fraas,[3] Sir William Dawson,[4] and Professor Edward Hull.[5] To the two former we are indebted for some of our earliest knowledge respecting the occurrence of fluviatile shells of Post-Tertiary age at high levels in the Nile Valley; and to the remainder for valuable information on the beaches and sea-beds found in the neighbourhood of the Gizeh Pyramid and the Mokattam Hills, formerly regarded by Fraas as of Miocene age, but which more modern observers have recognized as Pliocene.

Connected with the Quaternary history of Egypt, although not of conchological interest, reference should be made to the two important reports by Professor Judd[6] on the delta deposits of the Nile as examined by a series of borings carried out under the

[1] "Notes on the Geology of a Portion of the Nile Valley north of the Second Cataract in Nubia, taken chiefly with the view of inducing further Search for Fluviatile Shells at High Levels": Quart. Journ. Geol. Soc., vol. xx (1864), pp. 6–18.

[2] "Note on the Fresh-water Shells collected in Nubia by Dr. Leith Adams": Quart. Journ. Geol. Soc., vol. xx (1864), p. 19.

[3] "Aus dem Orient," 1867, pt. i, pp. 161–7.

[4] "Notes on the Geology of the Nile Valley (Raised Sea-margins; Mokattam Terraces from the Nile)": Geol. Mag., 1884, pp. 289–292.

[5] "Memoir on the Geology and Geography of Arabia Petræa, Palestine, etc.," 1886, pp. 70–72.

[6] First Report, "On a Series of Specimens of the Deposits of the Nile Delta obtained by the recent Boring Operations": Proc. Roy. Soc. London, 1886, vol. xxxix, p. 213. Second Report, "On Specimens of Deposits of the Nile Delta obtained by Boring Operations undertaken by the Royal Society": ibid., 1897, vol. lxi, p. 32.

☞ Plates **XIX** and **XX**, illustrating this Article, will appear in the October Number.

auspices of the Royal Society to ascertain at what depth the solid rock might be reached, a result unfortunately not achieved, for after piercing the alluvial beds to a depth of 345 feet from the surface and 319 feet below sea-level at Zagazig, operations were suspended without meeting with the basal formation. The first of these reports deals with the mineral and chemical nature of the deposits, whilst the other includes some information upon the Foraminifera.

MOLLUSCA: GASTEROPODA.

Genus PLANORBIS, Geoffroy.

Traité Coq. Fluv. Terr. Paris, 1767, pp. 12, 81.

Type.—*Helix cornea*, Linnæus.

Planorbis Pfeifferi, F. Krauss. (Pl. XIX, Figs. 6–8.)

Planorbis Pfeifferi, Krauss: Die Südafrikanischen Mollusken, 1848, p. 83, pl. v, fig. 7.

Description.—*P. testa cornea, nitida, diaphana, oblique striata, utrimque (supra profundius) concava, umbilicata; anfractibus 5 convexis, mediocriter crescentibus, ultimo supra convexiusculo, infra inflato, $\frac{1}{3}$ totius diametri æquante; suturis profundis; apertura lunato-rotunda; peristomate simplice.* (Krauss.)—The shell is concave on both sides, though more so umbilically; it possesses from four to five convex whorls, the last one increasing very rapidly in width; suture deep; aperture roundly lunate; peristome simple; test obliquely striated.

Dimensions.—Diameter, 10 mm.; height, 4 mm.

Remarks.—A careful comparison has been made with recent examples of this species in the Zoological Department of the British Museum, the present Egyptian shells being found identical in every character. A Peruvian shell, *P. trigyrus* of Philippi,[1] appears to be closely related, though differing in its more orbicular aperture and lesser diameter. Another form, *P. Sudanicanus*, E. v. Martens,[2] is separated by its more convolute spiral system, a smaller umbilical area, and less lenticular shape.

Horizon.—Post-Pliocene (Lacustrine or Fluviatile Deposits).

Distribution.—Natal: Umgani Valley (Krauss). Egypt: near Farshut, Nile Valley. Coll. Geol. Surv. Egypt (No. 1,040, Box No. 52*c*).

Genus MELANIA, Lamarck.

Mém. Soc. Hist. Nat. Paris, 1799, p. 75.

Type.—*Helix amarula*, Linnæus.

Melania tuberculata, Müller. (Pl. XIX, Figs. 9–11.)

Nerita tuberculata, O. F. Müller: Verm. Terrest. Fluv. Testaceorum, vol. ii (1774), No. 378, p. 191.

[1] Malakozoologische Blätter, vol. xvi (1869), p. 39; Novitates Conchologicæ, vol. iv (1870), p. 25, pl. cxiv, figs. 13–16.

[2] Malakozoologische Blätter, vol. xvii (1870), p. 35; Novitates Conchologicæ, vol. iv (1870), p. 23, pl. cxiv, figs. 6–9.

Melania tuberculata, Brot, "Die Melaniaceen (Melaniidæ)": Syst. Conchyl.-Cabinet, 1874, p. 247, pl. xxvi, fig. 11. Edward Hull: Mem. Geol. Palestine, etc., 1886, p. 80.

Description.—*Nerita testa subulata, cinerea, transversim striata; anfractibus nodulosis, strigisque sanguineis.* (Müller.)

Remarks.—The Egyptian specimens referred to this shell exhibit the usual characters of the species. Numerous spiral lines ornament the moderately convex whorls, these being crossed by oblique rows of tubercles, which become more or less obsolete as the last whorl is reached. Hull records this species as occurring in a semi-fossil state in some marl terraces 20 feet high at Ain Abu Werideh, in the Jordan-Arabah country, which is about 1,400 feet above the level of the Dead Sea. For a further synonymy of the species Dr. Brot's work should be consulted.

Dimensions.—Length, 31 mm.; diameter, 11 mm.

Horizon.—Post-Pliocene (Lacustrine or Fluviatile Deposits).

Distribution.—Tripoli, Algeria, Egypt, Madagascar, India, Ceylon, Java, and Australia (Recent specimens). Palestine: Ain Abu Werideh. Egypt: near Farshut, Nile Valley. Coll. Geol. Surv. Egypt (No. 1,041, Box No. 53*c*).

MOLLUSCA: LAMELLIBRANCHIATA.

Genus ALECTRYONIA, Fischer (Waldheim).

Museum-Demidoff, vol. iii (1807), p. 269.

Type.—*Mytilus cristagalli*, Linnæus (*A. rara*, Fischer).

Alectryonia cucullata, Born. (Pl. XIX, Figs. 1–5.)

Ostrea cucullata, Born: Musæi Cæsarei Vindobonensis, 1780, p. 114, pl. vi, figs. 11, 12.

Ostrea Forskali and *Ostrea cornucopiæ*, Chemnitz: Conchylien-Cabinet, vol. viii (1785), p. 30, pl. lxxii, figs. 671*a–c*; p. 41, pl. lxxiv, figs. 679*a–b*.

Ostrea Forskali, Brocchi: Conch. Fossile Subapennina, vol. ii (1814), p. 566.

Ostrea undata, Lamarck: Hist. Nat. Anim. sans Vert., vol. vi (1819), pt. 1, p. 217. Basterot: Mém. Soc. Hist. Paris, vol. ii (1825), pt. 1, p. 1. Serres: Géognosie Terr. Tertiaires France, 1829, p. 136, pl. vi, figs. 4, 5.

Alectryonia cucullata, Chenu: Manuel Conchyliologie, 1862, p. 197.

Ostrea cucullata, and vars. *comitatensis, occitania, Ruscinensis*, Fontannes, "Môll. Pliocène Rhône et Roussillon": Invert. Bassin Tert. Sud-est France, vol. ii (1879), p. 228, pl. xvii, figs. 7–9; pl. xviii, figs. 5–7.

Ostrea pseudo-cucullata, Fuchs: Palæontographica, vol. xxx (1883), p. 36 (54), pl. xix (xiv), figs. 10–13.

Alectryonia (*Ostrea*) *cucullata*, Viguier, "Etude Pliocène Montpellier": Bull. Soc. géol. France, sér. iii, vol. xvii (1889), p. 413, pl. x, figs. 2–5.

Ostrea cucullata, Ficheur: Desc. Géol. Kabylie du Djurjura, 1890, p. 382.

Ostrea cucullata, var. *Byzacena*, P. Thomas, "Desc. quel. Foss. Tunisie": Explor. Scient. Tunisie, 1893, p. 21, pl. xiii, figs. 6–11.

Ostreola Forskali, and vars. *undulatior*, *perrostrata*, *subcucullata*, *persacellus*, F. Sacco: Moll. Tert. Piemonte, pt. xxiii (1897), p. 16, pl. v, figs. 1–3 and 6–12.

Description. — Shell oblong in shape, with plicated valves. The lower or convex valve deeply excavated, of variable width, with sometimes nearly parallel sides, and furnished with an elongate, straight, or curved ligamental rostrum, with its summit usually directed backwards, and bearing a moderately deep triangular fossula; interior of more or less rectangular form, and ornamented externally with a few slightly-elevated radial costæ crossed by a regular series of growth-lines. The upper valve is depressed, somewhat lamellose, oblong, frequently narrow at the ligamental area, exhibiting on the outer surface some obscure longitudinal plications; the muscular-scar impressions are superficial and scarcely perceptible.

Remarks.—The Egyptian specimens referred to this species are exactly comparable, not only with the living representative as it occurs off the shores of the Red Sea, but also with some Italian Pliocene forms that have been examined in the British Museum (Natural History)—No. 80,943—and which are labelled as *O. undata*, the equivalents of Born's *O. cucullata*. Much more elongate ligamental rostra appear to distinguish specimens from the Pliocenes of Tunis, Montpellier, and the Rhône Basin, the Tunis specimens being also more numerously plicated than others. It is undoubtedly a most variable mollusc, and authors are pretty generally agreed that it should embrace *O. Forskali* and *O. cornucopiæ* of Chemnitz, as well as Lamarck's *O. undata* as figured by Serres. Certain distinctions have been pointed out in this species which are said to be more or less constant at the various localities where it has been found, thus giving rise to the introduction of a number of varietal names by such writers as Thomas, Fontannes, Viguier, and Sacco; but although these details are carefully worked out, they do not appear to be adapted for general application. Under *O. Forskali*, Chemnitz alludes as far back as 1785 to the discovery of this mollusc in a fossil state in Egypt by Professor Forskal. From late Tertiary deposits near Cairo, Fuchs has described and figured an oyster called *O. pseudo-cucullata*, which cannot possibly be separated from Born's species; it corresponds exactly with an example of similar dimensions from the Pliocene (Astian) of Italy. In confirmation of this opinion, it is satisfactory to know that Dr. Schweinfurth came to the same conclusion some years since, and the fact was published by Sir William Dawson in his paper on "The Geology of the Nile Valley" (Geol. Mag., 1884, p. 298). The specimens are of variable dimensions and somewhat fragmentary; they occur in a soft, green,

sandy matrix, accompanied by crystals of selenite, and beneath some beds containing vertebrate remains (*Hippopotamus*, etc.). On account of their striking resemblance to Italian forms they are regarded as of Pliocene age.

Horizon.—Pliocene (probably Astian) : in the Lake Deposits of Wadi Natrun at the hill known as 'Moluk.'

Distribution.—Red Sea, etc. (Recent); Tunis, Montpellier, Rhône Basin, Italy (Pliocene), Algeria: Kabylie (Sahelian or Tortonian). Egypt: near Cairo (Fuchs); Moluk Hill, Wadi Natrun. Coll. Geol. Surv. Egypt (No. 327, Box No. 1*a*).

Genus UNIO, Retzius (Philipsson), 1788.

Nova Testaceorum Genera, 1788, p. 16.

Type.—*Mya margaritifera*, Linnæus.

Unio Willcocksi, sp. nov. (Pl. XX, Figs. 1–4.)

Unio 'lithophagus' (?), S. P. Woodward : Quart. Journ. Geol. Soc., vol. xx (1864), p. 19 (list name only, no text) ; *non* (Ziegler) Philippi.

Description.—Shell large, elongate, convex, robust, and ornamented with concentric growth-lines, which are more or less rugose according to age; posterior region oblique, produced and decreasing in width, anterior margin rounded and short; ventral area usually with median depression; umbones anterior, small, eroded, without corrugations; left valve possesses two divergent cardinal teeth, with two minor ridges between; posterior lateral teeth elongate.

Dimensions (of a right valve). — Height, 48 mm.; length, 84 mm.; diameter, 17 mm.

Remarks.—This species is closely related to the recent African form of *Unio Caffer*, Krauss ("Die süd Afrikanischen Mollusken," 1848, p. 18, pl. i, fig. 14), but differs in its more elongate shape, the greater length of the postero-lateral teeth, the absence of umbonal wrinkles, and in the more rugose character of its concentric sculpture. One of the present specimens has its umbonal region entirely denuded of the prismatic layer, thereby showing a complete cast of the interior of the early shell in which the pallial line and muscular-scar impressions are clearly discernible. Many years ago Dr. Leith Adams collected some *Unios* from the alluvial deposits of Nubia at a height of 150 feet above high Nile at the Second Cataract, which the late Dr. S. P. Woodward identified as *Unio 'lithophagus'* (?), but gave neither description nor figure. An examination of these shells in the Geological Society's Museum has proved the fact that they are precisely the same as the species now described, but as they differ from *U. lithophagus*, which is a manuscript species of Ziegler and equivalent to *U. teretiusculus* of Philippi, it is necessary to establish another name, and therefore that of *U. Willcocksi* is proposed, in recognition of the collector of the specimens, which now form part of the Museum of the Geological Survey of Egypt. It may be of interest to state that *U. teretiusculus* (= *U. lithophagus*) from the White Nile is of much more slender form, of a nearly

uniform height throughout, and with no posterior oblique attenuation. In referring to the stratified Quaternary deposits at Ombos (= Kom Ombo), Leith Adams remarks that they measured 80 or 90 feet in height, but so far as he could ascertain yielded no organic remains. Mr. Willcocks' discovery of this new *Unio*, from probably the same spot at about 8 metres above the present high Nile, adds a further interest to this locality. The specimens were found associated with vertebrate remains (reptiles, fishes, etc.).

Horizon.—Post-Pliocene (Fluviatile Deposits).

Distribution.—Nubia: Second Cataract. Egypt: Kom Ombo (= Ombos of Leith Adams), lat. 24° 2′ 30″ N., at about 8 metres (= rather more than 26 feet) above present high Nile. Coll. Geol. Surv. Egypt (No. 647, Box No. 23*b*).

EXPLANATION OF PLATE XIX.

Alectryonia cucullata, Born, sp. Pliocene (Astian ?), Moluk Hill.

Fig. 1.—Front view of two lower valves, united laterally.
Fig. 2.—Back view of a lower valve exhibiting the plications.
Fig. 3.—Fragment of the ligamental region of another lower valve, rather longer than usual, and evidently belonging to an older form than the other specimens.
Fig. 4.—Upper valve, interior.
Fig. 5.—Upper valve, exterior, showing obsolete plications.

Planorbis Pfeifferi, Krauss. Post-Pliocene, near Farshut (× twice nat. size).

Fig. 6.—Profile of shell, showing the aperture.
Fig. 7.—Upper surface of shell, showing the depressed whorls.
Fig. 8.—Under surface of shell, showing the umbilicus and aperture.

Melania tuberculata, Müller, sp. Post-Pliocene, near Farshut.

Fig. 9.—Front view of largest specimen, showing aperture.
Fig. 10.—Back view of the same specimen.
Fig. 11.—Magnified view of sculpture.

EXPLANATION OF PLATE XX.

Unio Willcocksi, sp. nov. Post-Pliocene, Kom Ombo.

Fig. 1. } Interior and exterior of right valve.
Fig. 2. }
Fig. 3.—Interior of a left valve.
Fig. 4.—Exterior of a left valve, showing impression of the early shell.

[Except where otherwise stated, the figures on both plates are drawn natural size.]

NOTICES OF MEMOIRS.

The Islands and Coral Reefs of Fiji. By Alexander Agassiz. (Bulletin of the Museum of Comparative Zoology, Harvard College, vol. xxxiii.) 8vo; pp. 168, with 120 plates. (Cambridge, Mass., U.S.A.; May, 1899.)

PROFESSOR ALEXANDER AGASSIZ deserves the thanks of all naturalists for this splendid contribution towards the recently much disputed subject, the origin and mode of formation of coral reefs. This is an age of critical examination, and no man, however beloved and esteemed amongst his fellow scientific men, can propound a theory which shall long remain unchallenged. That Darwin's theory remained accepted and undisputed for fifty years

speaks well for the careful and thoughtful observations on which it was based, and, like all the work of this illustrious naturalist, it commended itself to everyone by its clearness and simplicity.

Before proceeding to give an account of his expedition to Fiji Alexander Agassiz devotes a few pages to an examination of some of the literature of coral reefs.

The Literature of Coral Reefs.

"In many quarters" (writes Agassiz) "it has become a question of creed to uphold the Darwinian theory of subsidence as essential to the formation of atolls and of barrier reefs. Facts and arguments supporting other explanations are ignored or explained away in the most extraordinary manner. Regions which are cited by Darwin and Dana as typical become exceptions when shown to be no longer characteristic regions of subsidence. Typical barrier reefs become patch reefs, atolls are dubbed pseudo atolls; so that the regions where true barrier reefs or typical atolls, which owe their origin to subsidence, can be examined, are little by little becoming very restricted. In fact, if we are to judge of the regions not yet examined, and which have not been examined by Darwin and Dana, there remain as extensive regions of possible subsidence only such islands as the Marshall and Carolines, some of the atolls of the Gilbert and Ellice groups, and of the Paumotus. Yet, judging by analogy, of the adjoining districts of Fiji and Tonga, and of the descriptions given by Dana of the Paumotus, and by what we may gather from the charts in the light of our own exploration, it would not be launching a very doubtful proposition to assert that even in these island groups we shall find that the explanation we have given of the formation of atolls and of barrier reefs applies equally well to them. This still leaves the field open for observations in some of the coral regions of the Indian Ocean, and of the East Indian Archipelago. But in the districts which have been described as typical by both Darwin and Dana, recent observations have shown that other and more natural explanations than the theory of subsidence are sufficient to account for the formation of atolls and of barrier reefs.

"As is well known, Darwin's experience among coral reefs was limited to a part of Tahiti, to the west side of Mauritius, and to the Keeling Atoll. Though he passed through the Paumotus without examining any of the islands; according to the narrative of the 'Beagle,' Darwin saw in the distance Honden Island, passed by Taiaro along the shore of Kauehi and sailed between Elizabeth Island and Fakarava (Wittgenstein) to Otaheite. Captain Fitzroy also sailed through the Navigator, Friendly, and Fiji Islands without anchoring anywhere. Dana worked among the reefs at Tahiti, Samoa, and the Feejees, though he did not visit the Eastern Archipelago, limiting his observations to the larger islands, Viti and Vanua Levu and Ovalau. He 'twice visited the Hawaian Islands, landed and gathered facts from fifteen coral islands, some of them in the Paumotu Archipelago; one, Tongatabu, in the

Friendly group; two, Taputeaua and Apia, in the Gilbert group, and five others near the equator, east of the Gilbert group; Swain's Fakaofu, Oatafu, Hull and Enderbury Island, as well as the reef region of the Sooloo Sea and of the Straits of Malacca.'

"In my account of the coral reefs of the Sandwich Islands, I have given a short résumé of the results of the principal investigations on coral reefs since the days of Darwin and Dana down to 1889. What has been done since that time will be found referred to in Bonney's edition of Darwin's Coral Reefs,[1] in Kent's 'Great Barrier Reef,' in Langenbeck's sketches of recent work on the subject, as well as in the reports of the explorations I have carried on in the Bahamas and Cuba, the West Indies, Florida, and the Bermudas in the Atlantic, and of the expeditions I have made to the Galapagos, the Great Barrier Reef of Australia, and Fiji.

"An excellent account of the Samoan Reefs has been published by Dr. Krämer, supplementing the earlier short notice of Dr. Graeff on the reefs of the group; also interesting notes by Admiral Wharton, on Submarine Banks of the Pacific. A careful account of the geology of the Friendly Islands by Lister, published in 1891, seems to have escaped the attention of writers on coral reefs. A few notes on the reefs of some of the islands of the Bismarck Archipelago have been published by Dr. Dahl, but the evidence he gives does not seem to me to warrant his conclusions. The great thickness of elevated reef he found (570 m.) may (as is the case elsewhere in the Pacific) not belong to the present epoch, as he takes it for granted, and no one supposes that elevation has necessarily always taken place uniformly either in time or space over any great stretch of territory.

"The articles by Heilprin and by Ortman on what they call 'Patch Reefs,' do not seem to me to have any special bearing on the general theory of coral reefs. The existence of such 'patches' has long been known and referred to by Darwin, and by many writers on coral reefs, as reef patches. These patches occur in localities where fringing reefs for local causes would not flourish except at a little distance from shore and play a very subordinate part in the

[1] Professor Bonney ("Coral Reefs," Darwin, 1889, 3rd ed., Appendix ii, p. 290), has evidently confounded the views of Professor L. Agassiz on the extent of the formation of the southern extremity of Florida by coral reefs, dating back to 1854, with those which I have published in 1877, in 1880, in 1888, and again in 1896. Neither Dall or Heilprin has examined the Florida reefs; their studies have been devoted to other parts of the peninsula, and did not extend south of the northern limit of the Everglades. Their criticisms in both cases apply to the views of Professor L. Agassiz, as my observations were limited to the reef region, and did not encroach on the area examined by Dall or Heilprin. But I have plainly shown by the borings at Key West that the recent coral formation is of moderate thickness, not more than about fifty feet, and that it is underlaid by a substratum of Tertiary limestones, occasionally coralliferous, of a thickness of nearly two thousand feet. The area probably covered by the coral reef of Florida at the time of its greatest expansion is approximately shown on plate xvii, Bull. Mus. Comp. Zoöl., vol. xxviii (1896), No. 2. I never made the statement quoted by Bonney that the recent coral reefs extended over any part of Florida north of the Everglades. On the contrary, I said in the conclusion of my memoir on the Tortugas and Florida Reefs (Mem. Am. Acad., vol. xi, 1883, p. 116), "All this evidence tends to show that the coral reefs had little, if anything, to do with the building up of the peninsula of Florida, north of Cape Florida."

physiognomy of the coast. I am at a loss to understand the statements of Ortman regarding the reefs of Kaneohe Bay on the north shore of Oahu. The accurate observations of Hartt and of Rathbun on the moderate thickness of coral reefs off the coast of Brazil seem to have escaped Heilprin and Ortman, as well as other writers on coral reefs. Rathbun has described the reefs along the Brazilian shore, and finds them all as 'having very little height, but from the surface looking like massive structures.' Hartt and Rathbun have described the formation of extensive coral patches and the mode of building up columnar masses which may eventually reach the surface forming mushroom- or even bell-shaped structures, of which enlarging rims may meet, 'resulting in the formation of a connected reef surface supported by many upright pillars underneath from forty to fifty feet high,' the so-called 'chapeirões' of the Portuguese. These patches frequently occur near the shore along the margin of a fringing reef, but are best developed in the deeper water of the Abrolhos regions and between these and the city of Bahia, growing upon the submerged rocky ledge. The number of reef building corals in Brazil is quite small, and Nullipores seem, according to Rathbun, to play a very important part in the building up of the limestone reefs.

"Professor Bonney summarizes the position of the theory of coral reefs as now left (1889) in the following terms: 'That this theory may have been expressed in terms a little too comprehensive, that there may be a larger number of exceptional cases than was at first supposed, is quite possible. . . . . It may very possibly be found that, as remarked by Mr. Bourne, the history of coral reefs is more varied and complicated than was at first supposed, but it seems to me that, as the evidence at present stands, it is insufficient to justify a decision adverse to Mr. Darwin's theory as a general explanation.'

"Professor Bonney, in spite of his intention to present an absolutely unbiassed expression, has, in common with most geologists not familiar with coral reefs, retained the view of the correctness of Darwin's theory. It can scarcely be said that the earlier examinations of coral reefs were made with the detail which has characterized the later explorations. The original work of Darwin was limited to a narrow field, and supplemented by data derived from charts and descriptions. Its correctness depends wholly upon the existence of masses of coral reefs of great thickness, where coral reefs exist as barrier reefs or atolls, and having assumed this the rest naturally followed. For no one will deny that subsidence is one of the possible modes of formation of masses of limestone of great thickness. But subsequent observers showed most distinctly that both atolls and barrier reefs occurred in regions of elevation. These exceptions are not limited to a single area. They occur in regions of the globe widely separated. While it undoubtedly is true, as remarked by Professor Bonney, that Darwin has noticed most of the causes on which stress is laid by his critics, it should also be remembered that Darwin did not observe the phenomena subsequently examined,

but merely suggested them as possibilities, and his critics may be excused for giving their observations a relatively greater value than to his theoretical views.

"The whole argument of the great thickness of coral reefs based upon the analogy of the so-called raised reefs of Cuba, described by Professor Crosby and myself, or of the fossil reefs, is of little value, as it has been pretty conclusively shown that these elevated reefs, not only in Cuba but in the Pacific, are beds of Tertiary limestone intercalated with beds of moderate thickness in which corals are found, and the same is true of older fossil reefs. Furthermore, these huge masses of Tertiary limestone which form the substratum upon which both in Cuba and in the Pacific recent corals have found a footing, have played no part in the shaping of the barrier or encircling reefs, or atolls, which, as we have attempted to show, owe their origin in the main to mechanical causes.

"Professor Bonney states that 'Much stress is laid upon the fact that many coral islands afford evidences of a certain amount of upheaval; this amount, in most cases, is but slight, and its significance appears to me to have been exaggerated'; and he considers these indications to prove only oscillation. As far as the Fijis are concerned, the elevation extended over the whole group, and has been shown to amount to more than a thousand feet. In Australia it extended along the whole east coast of Queensland for more than a thousand miles, and was more than twenty-five hundred feet in height! He further says, 'If the coral reef be only a sort of cap concealing a hill of pre-existent rock, we may reasonably be surprised that the "ashlar rock" of coral limestone has in no case so far yielded to the action of the atmospheric agencies as to lay bare its inner support.' We can answer this point most decidedly. In Florida the substratum underlying the recent coral reefs crops out at many places, and the highest points of some of the Keys consist of it. So do some of the hummocks in the southern part of the Everglades near Key Biscayne. In the Bermudas the greater part of the land of that group consists of the æolian rocks which underlie the recent coral reef. In the Bahamas the same is the case, and along the northern coast of Cuba the Tertiary limestone forming the substratum of the recent reefs crops out in all directions, while in Australia rocks underlying the Great Barrier Reef can be traced as islands, islets, or negro-heads all along its line for more than a thousand miles. Finally, in the description of the islands of Fiji this substratum appears over and over again, either composed of volcanic rocks or of great Tertiary limestone banks. No better example can be found of the appearance of the substratum of the recent reefs than in Kaneohe Bay, Oahu, at the Sandwich Islands, where the reef is studded with islets and negro-heads consisting of volcanic rocks.

"That corals grow in lagoons is well ascertained, and nowhere is it better seen than in Fiji, where nearly all the islands enclosed by barrier reefs are edged with fringing coral reefs. But why that should prevent a lagoon from being formed I cannot see. A lagoon

is not bounded by a reef forming a closed wall rising well above the level of the sea. The greater part of the reef of many a lagoon of an atoll or barrier reef has from two to three fathoms of water upon it at high tide. The reef is also riddled on all sides with narrow channels or openings with from one to two fathoms or more at low tide, in addition to the wider and deeper passages to leeward, through which access is gained into the lagoon. But for all this the lagoon exists, while it may not have more than a few fathoms in maximum depth. This, however, does not prevent the coral heads on the inner slope of the reef from gradually becoming connected with the reef, and from encroaching little by little, but very slowly, upon the outer margin of the lagoon to a depth of seven or eight fathoms, at which the growth is checked either from the sediment accumulating on the floor, or from the strength of the currents scouring the bottom of the lagoon. The amount of dead coral which is ground up upon a reef flat is considerable. Much of it is cemented together and forms a breccia in the cavities of the coral heads, or in the open spaces between them. Still more of it is changed into sand and mud, which cover the floor of the lagoons of barrier reefs and of atolls, and finally a quantity is carried off in solution after the dead coral has become thoroughly rotten and crumbling.

"Darwin also visited the western side of Mauritius, where, he says: 'It is probable that a reef on a shelving shore, like that of Mauritius, would at first grow up not attached to the actual beach, but at some little distance from it; and the corals on the outer margin would be the most vigorous. A shallow channel would thus be formed within the reef, and this channel could be filled up only very slowly with sediment, for the breakers cannot cut on the shores of the island, and they do not often tear up and cast inside fragments from the outer edge of the reef, while every streamlet carries away its mud through breaches in the reef. . . . . A fringing reef, if elevated in a perfect condition above the level of the sea, would present the singular appearance of a broad dry moat bounded by a low wall or mound.'

"Darwin, when meeting Semper's objection that the existence of atolls or barrier reefs in a region of elevation was a fatal argument against his (Darwin's) views, is obliged to say that therein 'seems to me no improbability in their having originally subsided, then having been upraised . . . . and again having subsided.' He further says, 'The existence of atolls and of barrier reefs in close proximity is manifestly not opposed to my views.' Certainly not, but their existence in an area of elevation as claimed by Semper is. Darwin also says that, 'When the land is prolonged beneath the sea in an extremely steep slope, reefs formed there during subsidence will remain closely attached to the shore, and will be undistinguishable from fringing reefs.' This seems to me impossible. The disintegration of the inner edge of the fringing reef, the action of the sea upon this disintegrated material, the solvent action of sea water, all will tend to form a channel between the outer parts of the

reef and the shore, as is evidently the case in almost all fringing reefs, which show either an incipient channel where boats may circulate at high water, or a belt of considerable width in which the coral fringing the land has been killed by the silt brought down from the adjacent slopes, and has been decomposed, and, crumbling to sand or mud, is gradually being carried off at each high tide, forming a channel which when wide enough and deep enough becomes sufficiently prominent to change the fringing reef into a barrier reef.

"The difficulties encountered in attempting to meet the many suggestions made by Darwin regarding reefs which he did not examine are well exemplified in the account which he gives of Rose Island, one of the Samoa group.

"Bonney similarly takes Dana's account of the eastern half of the Fiji Archipelago, as if it were based upon actual observations. Dana did not visit that part of Fiji, but derived his information from the surveys of these islands made by the officers of the United States Exploring Expedition. His statements are derived from the charts."

General Sketch of the Fiji Islands and Coral Reefs.

The following is a general sketch by Professor Alexander Agassiz of the Fiji Islands and coral reefs:—

"I went to the Fijis under the impression that I was to visit a characteristic area of subsidence; for according to Dana and Darwin there is no coral reef region in which it is a simpler matter to follow the various steps of the subsidence which has taken place. Dana, in his last discussion of the coral reef question, states that it is impossible to find a better series of islands than the Fijis to illustrate the gradual changes (brought about by subsidence) which take place in transforming a volcanic island with a fringing reef to one with a barrier reef, or to one with an encircling reef ring, and finally to one in which the interior island has disappeared and has left only a more or less circular reef ring. For these reasons one of the Fiji atolls promised to be an admirable location for boring and settling the question of the thickness of the coral reef of an atoll.

"My surprise was great, therefore, to find within a mile from Suva an elevated reef about 50 feet thick, and 120 feet above the level of the sea, the base being underlaid by what is locally called 'soapstone,' a kind of volcanic mud. The western extension of this reef can be traced at points along the north side of the harbor of Suva, the islands of Lambeko, Vuo, and Dra-ni mbotu, which are respectively sixty to seventy feet in height, being parts of an elevated reef extending to low water mark, and now planed off. It was this elevated reef or its extension westward which we traced from the Singatoka River to the Nandi Waters. A short distance inland from the mouth of the Singatoka there is a bluff of about 250 feet in height, composed of coralliferous limestone. This bluff is the inner extension of the elevated patches and limestone bluffs visible on the shore of Viti Levu. I am informed by Dr. Corney

that the islands of Viwa and Asawa i lau, to the northward of the Nandi Waters, are also remnants of this elevated limestone.

"But the traces of extensive elevation are not limited to the island of Viti Levu. I found that the islands on the rim of the atoll of Ngele Levu consisted entirely of coralliferous limestone rock, elevated to a height of over sixty feet on the larger island. The northern sides of the smaller islands Taulalia and Tai ni mbeka, as well as the north shore of Ngele Levu, were on the outer edge of the rim of the lagoon, deep water running up to the shore line. We next found that at Vanua Mbalavu the northern line of islands were parts of an elevated reef, forming vertical bluffs of coralliferous limestone rock which had been raised by the central volcanic mass of the main island to a height of 510 feet at Ngillangillah, at Avea to 600 feet, at the Sovu Islands to 230 feet, and on the main island to a height of nearly 600 feet, while on the south of the main island the coralliferous limestone bluffs are very much lower, and those of Malatta and of Susui reach a height of 420 to 430 feet. Going farther west and south we find at Mango vertical bluffs of an elevated coralliferous limestone of over 600 feet underlaid by volcanic rocks at the sea level. At Tuvuthá the limestone bluffs are probably nearly 800 feet high. At Naiau they are more than 500 feet. At Lakemba they reach a height of about 250 feet on the south-west side of the island, the greater part of the rest of the island being of volcanic origin. On the island of Aiwa the elevated limestone is fully 200 feet thick. In the Oneata group the highest point of the elevated bluffs is about 160 feet. South of the volcanic island of Mothe and enclosed within the same barrier on the island of Karoni, the reef is about 120 feet thick.

"On the three islands of the Yangasá group the elevated limestone attains a thickness of 240, 300, and 390 feet, and on Ongea, the most south-easterly cluster we visited, it attains a thickness of nearly 300 feet. At Fulanga the elevated limestone attains a thickness of 360 feet, at Kambara it is about 200 feet thick, and at Wangava it is perhaps over 300 feet; these islands may be in part volcanic. Finally, at Vatu Leile, the most westerly island we examined, the elevated reef forming the island is fully 110 feet thick.

"All this plainly shows that the western and southern part of Viti Levu, as far south as Vatu Leile, and the whole length of the windward islands of the Fiji group, from Ngele Levu on the north to Ongea on the south, have been subject to an elevation of at least 800 feet; and there is abundant proof that the greater part of the thickness of the elevated coralliferous limestones has been eroded so as to reduce it in certain localities to the level of the sea, or in others to leave the bluffs and islands and islets of limestone which we have traced at so many points.

"Unfortunately there are as yet but few soundings among the islands of Fiji. There is a line extending from Nanuku Passage to the Kandavu Passage, and a number of soundings to the north of Wailangilala and towards Thikombia, which have developed the

existence of an extensive plateau with a depth of between 300 and 400 fathoms, from which rise all the islands forming the north-eastern extremity of Fiji. The soundings between Ngau and Viti Levu also indicate shallower water to the west of that island than is found either east or south of it. The deep water extends north-westerly in the passage, parallel with Kandavu. Deep water (1,200–1,700 fathoms) is found in the triangle formed by Moala, Totoya, and Matuku, showing the steep slope of Moala, from 1,200 fathoms at a distance of six miles, and of Matuku of 1,400 fathoms at a distance of five miles.

"The deep channel passing through the centre of the Koro Sea gradually deepens towards the south until it attains a maximum depth of over 1,400 fathoms east of Nairai and Ngau, becoming shallower towards Viti Levu. The water gradually deepens also in the Kandavu Passage from over 1,100 fathoms north of North Astrolabe Reef to over 1,900 fathoms south-west of Kandavu. The soundings to the north of Naitamba indicate a ridge with somewhat over 500 fathoms in depth connecting the plateaus on the two sides of Nanuku Passage. There are no soundings showing the depths between the larger clusters composing the Lau or eastern group of Fiji. It would add greatly to our knowledge of the connection of these groups to have lines of soundings connecting the different island clusters of Lau.

"All the evidence to be gathered in Fiji tends to prove that preceding the present epoch there was an extensive elevation, which lifted the great masses of coralliferous limestone resting upon the flanks of the islands to a considerable height, in some cases as high as 1,000 feet. The base of the limestone masses rests upon volcanic rocks, as can be seen at Suva, at Kambara, at Mango, at Lakemba, at Naitamba, and at Vanua Mbalavu it shows the thickness of the elevated reefs to have been over 800 feet. During this period of uplift the physiognomy of the islands of the group must have been greatly changed, and still further modified by the denudation and erosion which have taken place since the elevation of the ancient limestones. It is to the changes brought about by the elevation and the subsequent erosion and denudation that we must look for the causes which have fashioned the steep slopes of the islands and reefs, and not to the growth of the thin crust of corals which thrive upon the reef flats forming the substratum of the modern reef—a substratum which in Fiji may be of volcanic origin or composed of elevated limestone, the sea face of which is the extension of the former land mass and follows its ancient slope, being only slightly modified by the growth of the crust of recent corals found upon it.

"Similar elevated reefs (probably composed of the same Tertiary limestone as those of Fiji) have been described by Clark at the Loyalty Islands, and also by Chambeyron and Pelatan. Chambeyron gives figures of the elevated terraces of Lifou and Ouvea composed of coralliferous limestone, and there is an excellent photograph taken by Pelatan of the elevated coral reefs of Lifou, and reproduced in Bernard's 'Nouvelle Calédonie,' p. 45. While

Maré is said by Pelatan to have five terraces of elevated coralliferous limestone, and to be riddled with caverns, Clark considers the elevated coralliferous limestones of the Loyalty Islands probably to be Pleistocene.

"In the Solomon Islands Guppy has traced extensive elevated reefs, which, however, he considers as belonging to the present epoch. Elevated coralliferous limestones also exist in the New Hebrides, as well as on the southern shore of New Guinea.

"The time of this Fijian elevation we cannot at present ascertain. It is not unnatural to assume that it was coincident with the elevation of Northern Queensland, and that the area of elevation included New Guinea, the islands to the east of it as far south as New Caledonia, and as far east as the most distant of the Paumotus (Gambier Islands), and extended northward of that line to include the Gilbert, Ellice, Marshall, and Caroline Islands; and that since this epoch of elevation the islands within that area have been, like Northern Australia, subject to an extensive denudation and erosion, many of them being reduced to mere flats but a few feet above the surface of the sea, others worn away to represent to-day but a small portion of their former extent. It is upon the reef flats thus eroded, or around the islands and islets which are the remnants of a former period, that the corals of to-day have obtained a foothold. And further, by the mechanical action of the sea combined with that of the trade winds, channels have been excavated out of the substratum underlying the coral reefs to form the lagoons of the barrier reefs and atolls of Fiji.

"So that, as far as we can judge from the case of the Fiji Islands, the shape of the atolls and of the barrier reefs is due to causes which have acted during a period preceding our own. The islands of the whole group have been elevated, and since their elevation have, like the northern part of Queensland, remained nearly stationary, and exposed to a great and prolonged process of denudation and of aerial and submarine erosion, which has reduced them to their present height; the submarine platforms upon which the barrier reefs have grown being merely the flats left by the denudation and erosion of the central island, while the atolls are similar flats from the surface of which the islands have at first disappeared and the interior parts of which have next been removed by the incessant scouring of the action of the sea, the ceaseless rollers pouring a huge mass of water into the lagoon, which finds its way out of the passages leading into it or over the low outer edges of the lagoon. These atolls and islands, surrounded in part or wholly by encircling and barrier reefs, have not been built (as is claimed by Dana and Darwin) by the subsidence of the islands they enclose. They are not situated in an area of subsidence, but, on the contrary, in an area of elevation. The theory of Darwin and Dana is therefore not applicable to the Fiji Islands.

"The evidence of elevation is not limited to that furnished by the remains of the elevated coralliferous limestone just mentioned, and it is natural to assume that the elevation we have just traced was

but a part of a more general elevation, which perhaps took place in late Tertiary times, and in which the whole group was involved. It is plain that there must have been most extensive denudation and submarine erosion going on throughout the group for a very considerable time, geologically speaking. The outlines of the islands, deeply furrowed by gorges and valleys, the sharp or serrated ridges separating the valleys, the fantastic outlines of the peaks and chains of Viti Levu, Vanua Levu, and Ovalau, all attest to the great work of atmospheric agency which must have been going on for so long a period.

"The extent of the separation of the islands, islets, or isolated rocks from the points or spurs of the larger islands also bears witness to the great length of time during which submarine erosion and denudation have been at work.

"The platforms of submarine erosion constitute the characteristic features of the islands of Fiji. A glance at the sketch map of Fiji and at the detailed charts of different portions of the group cannot fail to show how extensive this action has been.

"Add to this the fact that we are in a region of a former powerful and extensive volcanic activity, the traces of which can still be seen in all directions, and which has undoubtedly played a great part in the lifting of the island masses and their subsequent shaping to their present outlines. From this evidence I am inclined to think that the corals of to-day have actually played no part in the shaping of the circular or irregular atolls scattered among the Fiji Islands; that they have had nothing to do in our time with the building up of the substructure of the barrier reefs encircling either wholly or in part some of the islands; that their modifying influence has been entirely limited in the present epoch to the formation of fringing reefs; and that the recent corals living upon the outer margin of the reefs, either of the atolls or of the barriers, form only a crust of very moderate thickness upon the underlying base. This base may be either the edge of a submarine flat, or of an eroded elevated limestone, or of a similar substructure composed of volcanic rocks, the nature of that base depending absolutely upon its character when elevated in a former period to a greater height than it now has; denudation and erosion acting of course more rapidly upon the elevated coralliferous limestones than upon those of a volcanic character. It is therefore natural to find that the larger islands, like Kandavu, Ovalau, and Taviuni, are of volcanic origin, while the islands which once occupied the area of the lagoons of Ngele Levu, Nanuku Reefs, Vanua Mbalavu, the Argo Reefs, the Oneata, Yangasá, Aiwa, Ongea, and Vatu Leile clusters, were composed of elevated coralliferous limestones. They have disappeared almost entirely, leaving only here and there a small island to attest to the former existence of a more extensive elevated limestone, once covering the whole area of what is now an atoll. Smaller volcanic islands, like Matuku, Moala, Ngau, Nairai, and Koro, also show the greater or smaller extent to which each has been eroded after its elevation, being least in Koro and Matuku, and somewhat more in Moala and

Ngau, and still more in Nairai; while in such volcanic islands with atolls as Mbengha, Wakaya, and Makongai the denudation and submarine erosion have been still greater, the islands covering but a comparatively small area of that once covered by the island originally occupying the area of the lagoon; this denudation having been carried to a still greater extent in the Kimbombo cluster, in Komo, and the islands of Duff Reef. This process of denudation and submarine erosion may have gone so far as to leave no trace in an atoll of its volcanic or of its limestone (elevated) origin, its shape to-day being entirely due to mechanical action, and having nothing to do with the growth of the corals which have found a footing upon the flats due to submarine erosion and to denudation and to the action of the atmosphere and of the sea.

"It seems to me as if the position of an island left on the western or lee edge of a lagoon depended upon the original position of its highest point. This appears in the case of Makongai and Wakaya. The crest of the former was probably near the eastern edge, while the highest point of Wakaya was perhaps nearest the western side of the original island. Similarly the highest summit and ridge of Vatu Leile, if our views are correct, was on the western face of the original land mass. The highest ridge of Rambe lies on the north-western side of the submarine plateau; the islands of Budd Reef indicate its highest land to have been on the northern part of the plateau.

"Admiral Wharton has suggested 'the cutting down of volcanic islands by the action of the sea, and that this action has a far greater share in furnishing coral foundations than has been generally admitted.' From our experience in Fiji we may safely modify this to the cutting down, not only of volcanic islands, but also of other elevated islands, and their cutting down not only by submarine erosion but also by denudation and atmospheric agencies, and thus preparing the foundations upon which recent corals have established themselves. Add to this the elevation of banks composed of volcanic rocks or of sedimentary rocks up to heights at which corals or corallines can begin to grow, and we have in addition to their increment in height from the increase due to pelagic organisms and the decay of other calcareous invertebrates living upon their surface all the elements needed for the preparation of a set of foundations from very different causes.

"I have already on other occasions called attention to the powerful scouring effect produced upon the interior of an atoll or lagoon, or the channel of a barrier reef, by the mass of water poured into it from all sides as the huge ocean swells break over the outer rim. This mass of water can find no outlet against the incessant swell; it must escape to leeward through the openings in the outer reef flats, or laterally over the low parts of their outer edges. It will be noticed that the openings are usually on the west face of the atoll, the direction in which the prevailing trades drive the water of the lagoon. The water becomes charged with particles of lime or of other material, and we soon have all the elements of a modified

gigantic pothole, from which the churned material is carried out by the currents flowing through the entrances into the lagoon. It has long been known that there is a violent rush of water out of the lagoons, the velocity attained reaching sometimes four to five knots. In Fiji I have noticed these powerful currents flowing out of the passages leading into the lagoons of Fulanga, of Ngele Levu, of Wailangilala, of Vatu Leile, of Totoya, and racing along the interior channels of the great barrier reef stretching along the south coast of Viti Levu, especially at Lauthala Bay, Suva, and the reef harbors and passages between Suva and Serua, and out of the smaller atolls like Motua lai lai, Thakau Leka leka, Thakau Momo, and others.

"The strength of the currents in the channel separating the barrier reef and the shore has been noticed by Semper and by Möbius as bearing an important part in Mauritius. There is in the *Biologisches Centralblatt*, 1889-90, Bd. ix, p. 564, a short review of the third edition of Darwin's 'Coral Reefs,' showing the principal points in the discussion of the reefs to which Bonney has called attention. But this discussion is mainly theoretical, and adds no new factors in the problem. I would refer to what Gardiner says regarding the conditions affecting the growth of coral reefs in Fiji, where he shows the effect of tidal currents in the passages of reefs and inside of reefs. Strong currents prevent the coral larvæ from fixing themselves in localities which they scour, while the corals will thrive off the passages where the currents have lost their strength. The navigators and naturalists of the U.S. Exploring Expedition frequently speak of the rapid outward current passing through the openings of the reefs, especially during the ebbing tide. Dana had noticed the great strength of the tidal currents, and he well explains by their action the great diversity of distribution of material over the bottom of a lagoon or of a barrier reef channel.

"There seems to be no question that the action of the sea can cut out the lagoons of barrier reefs and of atolls at the depths at which they have been observed in the Fijis. Although there are individual atolls which show depths of thirty-five to fifty fathoms and even more, these are exceptional depths, which are readily explained as due to other causes than the scouring action of the sea.

"Admiral Wharton has given an excellent summary of cases showing to what depths the action of the sea in motion may be felt to a sufficient extent to move material at depths of fifty to sixty fathoms. As he justly says, 'The effect [of the action of the waves in an otherwise deep sea over which strong winds are continually blowing] will be to cut down an island more or less rapidly, according to its constitution, to a very considerable depth below the surface, the final result being a perfectly flat bank.'

"The sections plainly indicate the general flatness of the lagoons, with a slight inclination in the direction of the flow of the water in the lagoon toward the ship passages leading into the lagoon, and the outline of the islands which have first been cut down by atmospheric agencies show irregularities which disappear finally when they have come within the scope of submarine erosion,

resulting in such 'sunken' banks as the Penguin Bank. By 'sunken' we do not mean in any way to refer to subsidence as a factor in producing such a bank. The mass of water which is poured into a lagoon on the windward face of a reef, and transforms it into a gigantic pothole, is something enormous. The breakers follow one another incessantly, and the hydraulic head obtained is amply sufficient to account for the scouring of the lagoons after the reef has once established itself as a bank, and amply sufficient to wear away from the slope of the islands the platform upon which the coral reef is built. The topography of this platform is naturally much varied, depending upon the character of the shore line; the direction of the valleys of the shore hills, and their composition. A glance at the charts accompanying this Bulletin will show all possible conditions of submarine erosion in the cutting down of the submarine platforms of the islands of Fiji, and in the manner in which islands, islets, and rocks have been left, attesting their former greater extension in the various clusters of the Archipelago.

"When the principal openings are not on the lee side of the lagoons, as is the case with Vanua Mbalavu, and the Argo Reef or Totoya, Fulanga, and a few others, there is usually a simple reason, such as the lower elevation of the island once covering the area of the lagoon at some point not on the lee side, or the fact that the lagoon has been formed on a steep volcanic slope looking eastward or northward, so that deep ravines or tongues of deep water cut into the lagoons, and intercept the coral patches forming its rim on the weather side, and thus leave a windward passage. It is by some such orogenic condition that we must explain the existence of deep soundings within atolls, — soundings which in no way indicate a subsidence, as has been assumed by Darwin, and which according to him were not to be explained by any other hypothesis. Such deep ravines are of course also to be traced on the slopes of the larger islands where we find, crossing the shallow plateaus on which coral patches grow, valleys of considerable depth, which appear as deep soundings within the area of an outer reef flat such as in the great plateau off Viti Levu and Vanua Levu, or of Kandavu and Taviuni, which according to Darwin would indicate a subsidence, while, on the contrary, they are a part of the results of the elevation and lifting up of that region of Fiji.

"Nor are the great depths found close to narrow lines of corals an indication that the corals have grown up as a nearly vertical wall from a depth of two or three hundred fathoms or more. It merely indicates that the corals form a thin crust, at most 120 feet in thickness, over a sharp volcanic ridge, the summits or crest of which have either reached by elevation the depths at which corals can grow, or have been denuded by submarine erosion to form a platform below the level of the sea, where corals have found a footing upon them.

"My observations in Fiji only emphasize what has been said so often, that there is no general theory of the formation of coral reefs, either of barrier reefs or atolls, applicable to all districts, and that

each district must be examined by itself. At least such has been my experience in the Bermudas, the Bahamas, Cuba, Florida, the West Indies, the Sandwich Islands, and Australia. The results of this trip show plainly that Darwin's theory is not applicable to the Fiji Islands, notwithstanding the borings at Funafuti, and that, in all the cases I have examined, the reefs form but a thin crust upon the underlying base, the shape and composition of which is not in any way due to the growth of corals of the existing period."

It is only possible to allude to the clearness and excellence of execution of the charts and the beauty of the illustrations. The work will be sought after and appreciated by all who are interested in the great question of the origin and the formation of Coral Reefs.

REVIEWS.

I.—The Palæontographical Society of London: Annual Volumes (li and lii) for 1897 and 1898. Issued to subscribers of one guinea annually, paid on 1st January to the Hon. Secretary, the Rev. Professor Thomas Wiltshire, M.A., D.Sc., F.G.S., 25, Granville Park, Lewisham, S.E.

THE fiftieth volume issued by this Society, for the year 1896, was reviewed by us in March, 1897 (see the Geol. Mag., 1897, Dec. IV, Vol. IV, No. 393, pp. 134–8). Since that date, vols. li (for 1897) and lii (for 1898) have been issued to subscribers, and vol. liii, for the present year, might appear at any moment, having already gone to the printers.

The salient points of the monographs contained in the last two years' volumes may now be briefly touched upon.

I.—The fourth (concluding) part of the Monograph of the Foraminifera of the Crag (1897) has been written by T. Rupert Jones, assisted by his highly competent allies, Messrs. H. W. Burrows, C. D. Sherborn, F. W. Millet, and F. Chapman, who have long been authorities on the history of the Microzoa forming the subject of this monograph. This Part (pp, vii–xv, 315–402, woodcuts 24–30; there are seven plates in the foregoing Parts I–III, and their figures are largely elucidated in this last Part) treats of some of the Rotalian group, and all of the known British Nummulinidæ, including several *Nonioninæ* and *Polystomellæ*, and some representatives of *Amphistegina*, *Operculina*, *Nummulites*, and *Orbitoides*, but the specimens of the four latter genera have probably been derived from older strata and left in the Crag of Sussex, whence they were obtained. The whole series of Foraminifera as known fossil in the English Tertiaries is thus completed, as begun in Part I (1866), but restated and continued in Part II (1895) and Part III (1896). Having been carefully collated with past and current rhizopodal literature, this well-illustrated monograph must prove to be a valuable guide to further research. Geologists will fully appreciate Messrs. Burrows and Holland's elaborate "Table of the Distribution of the

Foraminifera in the Crag and in some Contemporaneous Formations in Europe" (pp. 374–394), in which the occurrence of 410 genera and species in the several divisions of the Crag, and of the Pliocene of Belgium and of Italy, and one zone in the south of Spain, are carefully compared.

II.—A Monograph of the British Carboniferous Lamellibranchiata, by Wheelton Hind, M.D., etc. Part II, Mytilidæ, Arcidæ, Nuculidæ; pp. 81–200, pls. iii–xv (1897). The author has devoted time and labour to this useful work. The synonymies of the genera and of their many species are good evidence of this; and the several descriptions show conscientious work. The genera treated of are: *Posidoniella*, De Koninck, 9 species; *Naiadites*, Dawson (8 species were described in the author's monograph in 1895); *Myalina*, De Koninck, 7 species; *Parallelodon*, De Koninck, 22 species; *Nucula*, Lamarck, 8 species; *Nuculana*, Link, 6 species. Plates iii to xv illustrate these forms in abundant detail.

Part III, pp. 209–276, pls. xvi–xxv (1898). The Nuculidæ, continued; *Ctenodonta* has one species. Of the Trigonidæ [rightly Trigoniidæ] we have here *Schizodus*, 4 species; *Protoschizodus*, 13 species. Of the Unionidæ, *Anthracomya* is the type. Edmondidæ supply *Cardiomorpha*, with 9 species. The illustrations are numerous, and aim at the correct definition of all the features of the shells, both in external and internal aspect.

III.—A Monograph of the Carboniferous Cephalopoda of Ireland, by Arthur H. Foord, Ph.D., F.G.S., etc. Part I, Orthoceratidæ; pp. 1–22, pls. i–vii (1897). The author had produced a doctoral thesis with these fossils as its theme, and here the descriptions are reproduced with appropriate and good lithograph illustrations of full size. Grouping them as: A. *Longicones*; Group I, *Lævia*, and sub-Group *Cylindriformes*, he describes 12 species; sub-Group *Moniliformes*, 3 species. Of Group II, *Annulata*, 1 species. Of Group III, *Angulata*, 1 species. Of Group IV, *Lineata*, 4 species. Of Group V, *Imbricata*, 1 species. Most of these are new species.

Part II (1898) contains the concluding part of the Orthoceratidæ, and the families Actinoceratidæ, Cyrtoceratidæ, and the Poterioceratidæ, with 25 pages of letterpress and 10 plates. It is only right to say a word in praise of Mr. A. H. Crowther's excellent and careful lithographic plates of Irish cephalopods, drawn under Dr. Foord's own eyes in Dublin, as they are certainly among the best illustrations which the volumes contain. Dr. Foord's wide experience in the study of Cephalopoda in Canada, in the British Museum, and now in Dublin, renders his monograph of great scientific value to palæontologists.

IV.—A Monograph of the Devonian Fauna of the South of England, by G. F. Whidborne, M.A., F.G.S., etc. Vol. iii, pt. 2: The Fauna of the Marwood and Pilton Beds of North Devon and Somerset (continued); pp. 113–178, pls. xvii–xxi (1897). Some further results of the Rev. G. F. Whidborne's enthusiastic researches among the relics of an old Devonian fauna, badly preserved by nature in the strata of Devonshire, are here given.

Proceeding with the Bivalved Mollusca, he describes one more species of *Parallelodon*, one of *Modiolipsis*, one of *Modiola*, one of *Spathella*, and of *Digoniomya*, a proposed genus. Of the Aviculidæ, he has *Cobracephalus* (provisional), *Leptodesma*, *Leiopteria*, *Ptychopteria*, *Aviculopecten*, *Actinopteria*, *Pterinopecten*, *Crenipecten* (?), *Pleuronectites*, *Pernopecten*, and *Prothyris*. Numerous specimens of Brachiopods have been collected by the author from the strata referred to, and many of them, though distorted, are sufficiently recognizable as species of *Renssellæria* (?), *Athyris*, *Spirifera*, *Spiriferina*. *Rhynchonella*, *Orthis*, *Orthotetes*, *Strophomena*, *Productus*, *Strophalosia*, and *Chonetes*. The extreme care with which the author has come to a decision on the probable and possible affinities of the fossils passing through his hands is highly commendable, and enhances the value of his work very considerably.

In Part III, pp. 179–236, pls. xxii–xxxvii (1898), continuing with the Brachiopoda, we have *Chonetes*, *Crania*, *Discina*, and *Lingula*. Under 'Bryozoa,' which term he decides in an earlier monograph not to be so correct as 'Polyzoa,' but allowable to be used for convenience, he has *Fenestella*, *Pinnirétepora*, *Streblotrypa*, *Rhabdomeson*, *Leioclema*, and *Fistulipora* (?). *Cornulites* represents the Annulosa. Of the Echinodermata there are *Lepidestres*, *Protocidaris*, *Palæaster*, *Medusaster*, *Protaster*, *Eugaster* (?), *Ophiurella* (?), *Pentremitidea*, *Codonaster*, *Taxocrinus*, *Rhodocrinus*, *Megistocrinus*, *Mariocrinus* (?), *Actinocrinus*, *Platycrinus* (?), *Adelocrinus*, *Poteriocrinus*, *Scaphicrinus*, *Scytalocrinus* (?), and *Cæliocrinus*. It is pleasant to find among the foregoing several of the species formerly described by Professor John Phillips, but the 'types' of which have been difficult to find until Mr. Whidborne has devoted himself to these Devonian fossils both in quarries and in museums.

V.—In the fifty-second volume (for 1898), we find that Professor T. Rupert Jones and H. Woodward have contributed Part III to their Monograph of the British Palæozoic Phyllopoda (Phyllocarida), devoted to the genus *Dithyrocaris* (pp. 125–176 and pls. xviii–xxv). This genus contains some of the most beautiful forms of *Nebalia*-like Crustaceans, in which the bivalved carapace is borne upon the back of the cephalothorax, with the lateral margins of the valves more or less open, like a dorsal shield, as in *Apus*. The carapace in this genus is variously and beautifully ornamented, sometimes by striæ, sometimes by puncta or reticulate raised lines, in others by scale-like markings, and there are also raised lines and tubercles, reminding one of the ornamentation seen in *Pterygotus* and *Eurypterus*. The dorsal, lateral, and marginal ridges are likewise ornamented in various degrees and form. Abdominal segments, to the number of four, are seen in some examples projecting beyond the posterior border of the cephalothoracic buckler, as in *Nebalia*. These also are ornamented by waved lines, and terminate in three tail-spines, stiff, pointed, and ridged like bayonets. Most of them are of Carboniferous age, and occur in the coalfields of Scotland, Yorkshire, and Lancashire.

VI.—Mr. S. S. Buckman, F.G.S., contributes to the fifty-second volume (1898) Part X of his Monograph on the Inferior Oolite Ammonites of the British Islands, being a supplement to and revision of the Hildoceratidæ; with 4 plates and 32 pages of text. Mr. Buckman observes that "a thorough revision of the genera and species belonging to the family Hildoceratidæ is imperative, for two reasons: (1) because of the large accumulation of material, with so many new forms; (2) because the knowledge concerning the affinities of different species has necessarily become more complete."

If Mr. Buckman can only succeed in making this most difficult subject of the families and genera of Ammonites, such as the Hildoceratidæ, as clear to his readers as it is to himself, he will have earned the thanks of all the members of the Palæontographical Society as well as of geologists and palæontologists in general who attempt to decipher these beautiful and variable extinct Molluscan shell-forms. One result of Mr. Buckman's long study of the group is that he comes to the conclusion that "outward form is of merely subordinate value in classification. It is obvious that species most dissimilar in mere shape[1] can produce, by modification, specimens which are very similar." "Hence some other criteria of affinity must be sought for; and they are to be found in the characters of the ornamentation and suture-lines of the species. In comparison with the mere shape, both these features are constant. They are modifiable and they are modified; but they change so much more gradually than does the mere shape of the conch that they may, for practical purposes, be regarded as fairly stable. At any rate, they change so slowly that their identity is preserved." (p. i.)

In regard to the relative value of the suture-line and the character of the ornamentation as criteria of affinity, Mr. Buckman admits that the former undoubtedly holds the premier place. He contends, however, that in a group like the Hildoceratidæ the ornament is of great assistance.

Mr. Buckman gives tables of his revised system of classification, and we can only express a hope that they will be found capable of adoption by other workers: so shall he have praise of all men.

We congratulate the Secretary, the Editor, the Authors, and the Artists on the output of monographs during the years 1897–98 as reflecting the highest credit on the Palæontographical Society; and we trust that its ranks will be increased by the accession of fresh recruits, so as efficiently to maintain this costly warfare against the still formidable ranks of undescribed British fossils.

II.—The Origin of the British Flora. By Clement Reid, F.R.S., F.L.S., F.G.S. (London: Dulau & Co., 1899.)

THE publication of Mr. Clement Reid's book constitutes a welcome and valuable addition to palæobotanical literature; the volume contains in a small compass and in a clearly-written form the result

[1] Perhaps the differences observed "in mere shape" may be *sexual*, in that case the offspring would be "very similar."

of twenty years' work. The method of treatment adopted by the author is such as to inspire the reader with confidence; the greater part of the evidence which is adduced being the result of painstaking work by one who has proved himself not only an able geologist, but a keen naturalist, thoroughly equipped by contact with Nature, under varied conditions, to attack the problems which centre round the origin of the British Flora.

In the introductory chapter Mr. Reid tells us something of his methods of work: while availing himself of the assistance afforded by the herbaria of Kew and the British Museum, he soon found himself compelled to collect his own material, especially seeds and fruits, to compare with the fragmentary relics of the Pleistocene vegetation. Making the most of his opportunities in the field, the author paid special attention to such biological phenomena as the dispersal of seeds, and other factors concerned in the struggle for existence among our native plants, which might enable him to more satisfactorily interpret the fossil records, and to appreciate the complex agencies connected with the origin of the present flora.

In chapter ii, entitled "The Present Flora of Britain," there are many useful notes on the influence of climatal conditions and other agencies of importance in determining the composition and distribution of the British flora. It is pointed out that Britain shows signs "of a geographical distribution of plants largely independent of that due to climate; or, perhaps we should say, not governed by existing climatal conditions." One of the peculiarities of the present flora, which it is difficult to understand, is illustrated by the occurrence of Pyrenean plants in the West of Ireland and in Cornwall and Devon. In speaking of the woodland flora Reid refers to the probability of such trees as the Horse Chesnut, Spanish Chesnut, Sycamore, Lime, and others, having been introduced by the Romans, who were in the habit of planting trees round their villas for shade and beauty.

The interest of chapter iii, dealing with a subject which, if treated fully, would occupy several times the space allotted to it, is considerably increased by a number of new and interesting facts based on personal observation. The spread of oak woods is no doubt intimately connected with bird-agency; the occurrence of oak seedlings in various situations where no mammal would take the fruits, and other facts, lead the author to conclude that rooks are mainly responsible for the dispersal of acorns.

Long-distance transport of large edible seeds may occasionally be due to rare accidents rather than to special adaptation, as illustrated by the following note:—"Some years ago I found in an old chalk-pit the remains of a wood-pigeon which had met with some accident. Its crop was full of broad beans, all of which were growing well, though under ordinary circumstances they would have been digested and destroyed." The avidity with which some of our native plants occupy a newly exposed tract of ground is neatly illustrated by the following description:—"When the new railway to Cromer was made, the turf and top soil were pared off for a long distance, but

nothing more was done for several months. Next summer the route of the line was marked by a scarlet ribbon, which could be seen stretching across the country, the newly-bared sub-soil having been taken possession of by a profusion of poppies."

In chapter iv the author gives an exceedingly interesting but cautious epitome, so far as evidence is available, of the rapid succession of small changes, which characterized the latest stages in the evolution of the British Isles. The reader is warned that the author has been "led to interpret the records somewhat differently from other geologists." The conclusions have not been arrived at without the careful examination of trustworthy data, and many readers will be inclined to agree with Reid's view that the records of mild interglacial epochs are of much greater importance than has been frequently assumed. The Ice Age has undoubtedly been exaggerated as a period of extreme Arctic conditions; it requires but a slight change in a temperate climate to bring about a wide-spread glaciation. It would seem highly probable that during the Pleistocene period the climate was "at least as commonly temperate as Arctic," and at two or more periods there was a sufficient accumulation of snow and ice to convert a temperate into an Arctic climate. This chapter gives us many glimpses of fascinating interest of the waves of life, which swept over Britain during the period of constantly changing conditions between the Pre-Glacial and the Roman age.

Chapter v consists for the most part of lists of plants from various localities, but it is prefaced by a brief account of the conditions under which the seeds, leaves, or twigs were preserved as fossils. A map showing the position of the various localities would have been a great convenience. It would have served a useful purpose if the author had given a more detailed description of the best methods of collecting and preparing the fossil fragments. A collector with the experience of Mr. Reid often forgets the ignorance and inexperience of the layman, who, if properly directed, might easily become an enthusiast, and carry out excellent work in so promising a field as that of Post-Tertiary Botany. In the Stockholm Museum of Palæobotany the writer has had the opportunity of seeing several specimens of Pleistocene plants carefully prepared by Dr. Gunnar Andersson by a method of which a full account has been published in a Swedish journal, and displayed in such a manner as to make the most of the material from the point of view of accurate determination and attractive exhibition. In a department confined to the study of fossil plants, like that presided over by Prof. Nathorst in Stockholm, this kind of work is more easily carried out than in England, where palæobotany has not reached the same level of official recognition.

Chapter vi treats of the former distribution of British plants, but with the exception of four introductory pages the information is given in a form more suitable for reference than for continuous reading. The species hitherto recorded from Pleistocene deposits in Britain include not more than one-sixth of the present flora. This

fact points rather to the need of further investigations such as Clement Reid has so ably conducted, than to the absence of so many existing species from the Pleistocene vegetation. Only six exotic species have as yet been discovered. As the author suggests, the number of such plants in the Pleistocene flora was no doubt much greater, but the difficulty of obtaining suitable material as an aid to the identification of seeds seriously hampers the recognition of extra-British species. The book concludes with a most valuable list of the plants so far obtained from deposits varying in age from Pre-Glacial to Roman, and it is comforting to find that the botanist may confidently consult the list as one which is very largely based on the determinations of a highly competent specialist.

On first turning over the pages of Mr. Reid's volume, the reviewer was glad to find what he at first took to be a bibliography of works referred to in the text, but on closer inspection he discovered that the publishers had utilized the end of the book as an advertisement of "Books and Pamphlets on British Botany, offered for sale at net prices." A list of papers dealing with Post-Tertiary Geology and Botany, including such works as Warming's excellent memoir on Œcological Botany and others on the distribution of plants, would have been a useful addition.

As already pointed out, Mr. Reid's book bears the stamp of careful and accurate work of the greatest merit; but one feels a little disappointed that he has not given a concluding chapter summarizing in a readable form the evidence at present available from which to draw conclusions as to the origin of the British Flora. Practical hints and suggestions as to the most promising lines of research would have added not a little to the value of the work as an incentive to geological and botanical investigation. One closes the book with a wish for more, and while congratulating the author on his sensible resolve to be as concise as possible and to restrict himself to sure ground, it may be fairly urged that a second edition would benefit by greater fulness and by the addition of one or two more chapters.

It may be asked to what extent does this memoir advance our knowledge as to the origin of the British Flora? The title of the book is perhaps somewhat misleading: the facts it contains may be compared with documents of supreme importance in the construction of a complex genealogical tree; there is much additional evidence which we may reasonably hope to obtain, but much also that we can never discover. The merit of this welcome contribution to our knowledge is, that the evidence it presents is of the highest value, because it is thoroughly trustworthy. To understand the gradual evolution of the British Flora as it exists to-day, we must considerably extend our retrospect beyond the period from which Mr. Reid begins his survey, when practically all the plants seem to have been identical with existing species. Without reflecting on the value of the work, it may be truly said to furnish us with data, much fuller and more valuable than any previously available, towards the compilation of the past history of our native plants; but in itself

the evidence cannot be regarded as more than sufficient to enable us to form a clearer conception of the latest stages in the development of the British Flora. A. C. S.

III.—The Genera and Species of Blastoidea, with a List of the Specimens in the British Museum (Natural History). By F. A. Bather, M.A., F.G.S., of the Geological Department. pp. x, 70. (London: printed by order of the Trustees, 1899.)

DR. WOODWARD states in the Preface that "this work was originally designed to form one of a series of 'Lists of Types and Figured Specimens,' similar to that issued last year for the Fossil Cephalopoda," but in this comparatively small group it was found possible to extend the work into a list of the Genera and Species of Blastoidea, with an account of the Specimens in the British Museum (Natural History). The scope of the work is well expressed by the author in his Introduction. "First, it attempts to provide a complete index to every name that has ever been applied to a real or supposed Blastoid genus or species. Secondly, it indicates which of those names are now considered valid, and which are believed to be synonyms, giving cross-references from the latter to the former. Thirdly, it cites the literature bearing upon the nomenclature of each species, the bibliographic details being placed under the name now valid. Fourthly, it catalogues all the specimens of Blastoidea contained in the Geological Department of the British Museum (Natural History) at the time of writing (March, 1899). Lastly, it designates more particularly those among them that are of historical interest, as type-specimens or as having been figured, and supplies full references to the literature bearing on each individual specimen."

According to the author the British Museum collection contains 1,223 specimens, representing eighteen out of the twenty-two genera assigned to the Blastoidea; and considering the number of types, figured specimens, and specimens of historical interest in the Museum, we think the author is fully justified in stating that "there can scarcely be any collection so representative of the class as a whole, or so rich in specimens of the highest scientific importance, as is that of the British Museum."

The preparation of such a work entails an enormous amount of tedious labour and research, and every worker in this group will, we are sure, be most grateful to Mr. Bather for compiling, and to the Trustees of the Museum for issuing, such a useful list.

IV.—Bollettino della Società Sismologica Italiana, Vol. IV, 1898.

WITH its 44 national and 9 foreign members, aided by a grant from the Government, the Italian Seismological Society has carried on its useful work for a fourth year. The last volume contains 28 papers.

The invention and improvement of recording instruments continue to engage the attention of Italian seismologists. Dr. Agamennone

gives the latest modifications of his electric seismoscope, and apparatus for the same purpose are described by Dr. Cancani and Mr. Guzzanti. Professor Tacchini refers to some old instruments in the possession of the Central Office of Meteorology and Geodynamics, and suggests that they might form the nucleus of a seismometric museum. Dr. Cancani discusses the different methods of registration; discarding the photographic method on account of its expense, he prefers mechanical registration by a fine point on smoked paper to that made by ink flowing from a balanced pen.

There are some useful investigations of recent earthquakes. Dr. Cancani describes the Adriatico-Marches earthquake of Sept. 21, 1897. Dr. Agamennone studies the pulsations of several distant earthquakes, namely, the Indian earthquake of June 12, 1897, the Turkestan earthquakes of August 15 and September 17, 1897, and the Haiti earthquake of December 27, 1897; the two papers on the Indian earthquake being among the most valuable that have yet been published by the Society. Dr. Papavasiliou completes his list of Greek earthquakes in 1897, and also furnishes the catalogue for 1895: work that will without doubt bear fruit in due season. A supplement of 255 pages contains the admirable records of Italian earthquakes (July–December, 1897) compiled by Dr. Agamennone, the chief assistant in the Central Office, and recently appointed to the important post of Director of the Geodynamic Observatory of Rocca di Papa, near Rome.

The newest branch of seismology is represented by two papers, besides those referred to in the last paragraph; one by Professor Grablovitz on the form of the slow oscillations in earthquakes, the other by Messrs. Agamennone and Bonetti on the different methods of determining the position of the epicentre in distant earthquakes of unknown origin.

The volcanic phenomena of the country are as usual the subject of careful study. Mr. R. V. Matteucci writes on the increase in activity presented by Vesuvius during the months of April and May, 1898. Professor Mercalli continues his valuable Vesuvian notices (January, 1897 — July, 1898), and Mr. Arcidiacono his equally useful accounts of the principal eruptive phenomena in Sicily and the adjacent islands during 1898. C. Davison.

REPORTS AND PROCEEDINGS.

Geological Society of London.

June 21, 1899.—W. Whitaker, B.A., F.R.S., President, in the Chair. The following communications were read:—

1. "On a Series of Agglomerates, Ashes, and Tuffs in the Carboniferous Limestone Series of Congleton Edge." By Walcot Gibson, Esq., F.G.S., and Dr. Wheelton Hind, F.R.C.S., F.G.S. With an Appendix on the Petrography of the Igneous Rocks by H. H. Arnold-Bemrose, Esq., M.A., F.G.S.

After referring to the discovery of volcanic rocks in the upper part of the Carboniferous Limestone Series at Tissington, the authors proceed to describe evidence of volcanic action of the same age on the western slopes of Congleton Edge. This ridge is capped by two beds of Millstone Grit separated by black shales. Below the lower grit (the 'Third Grit') is a narrow dome of limestone lying in the midst of so-called 'Yoredale Shales' and exposed in an old quarry. The upper beds of the Limestone consist of thin shales and limestones containing one important and some minor seams of tuff and agglomerate, and certain evidence points to the probability that a 'neck' occurs in the quarry. A brook-section north of the quarry exposes beds of ash and tuff interstratified with shales and limestones, the thicker beds being presumably equivalent to those seen in the quarry. A brook-section south of the quarry displays the beds between the Limestone and the 'Third Grit,' and a small quarry yields a varied marine fauna.

In the Appendix it is stated that the igneous rock of the quarry is either a volcanic agglomerate filling a vent, or a thick deposit of very hard, coarse ash, probably formed not far from a vent. Ashy material in the Limestone indicates that the volcanic action was contemporaneous with the deposition of the Limestone. Two kinds of lapilli occur—one palagonitic, without crystals, and a second doleritic, free from vesicles, and containing felspar, olivine, and often augite; the latter type, though common in the agglomerate, is rarer in the bedded tuffs. The fragments are frequently altered into calcite.

2. "On some Ironstone Fossil Nodules of the Lias." By E. A. Walford, Esq., F.G.S.

In the Lias of Oxfordshire some ironstone-nodules are found at the point of contact of the Middle and Upper Lias. "The Middle Lias stone is compact, crystalline, and absorbent, and contains numerous irregular pyriform bodies," some of which "are changed wholly into a form of red hæmatite. These . . . . bodies have a circular vertical canal or shaft . . . . with the polyp and zooid-cells ranged round in obscure spiral growth. The cells have the areolated structure of the crinoids, or are spiculate of the type figured by Sars in *Pennatula*. Though in form approaching the *Cumacea*, the presence of perforated brachial plates, of annulated segments, and of spiculate zooidal cells, places the group between the *Pennatulæ* and the Crinoids. The resistance of the denser structure of the beds of calcareous stems of the rag-beds has caused the beds above and below them to become the lines of drainage, and hence [to become converted] into beds of greater ferruginous concentration."

3. "Additional Notes on the Glacial Phenomena of Spitsbergen." By E. J. Garwood, Esq., M.A., F.G.S.

This paper contains the results of additional observations on the ice of Spitsbergen made by the writer in 1897. The inland ice visited occupies two distinct areas, separated by Dickson's Bay and

Wijde Bay. The radiating-point lies somewhat north-west of the centres of each area, with supplementary radiating-points on the north and east. The group of peaks including the Three Crowns may be regarded as nunatakkr. The valley-bound ground-ice does not necessarily travel in the same direction as that of the surface. The effect of nunatakkr on the surface of the ice-sheet was studied, and from this it was often found possible to infer the existence and position of buried mountain-ridges. On the stoss-seite of a nunatak moraine-material is often discharged. The movement of the ice has frequently converted the ice-bridges across crevasses into arches and tunnels, some of which carry part of the drainage of the ice-sheet.

Portions of old stranded ground-moraines, formed when the ice was more extensive, were sometimes found to have fallen upon the lowered ice-sheet and to be mingled with modern moraine-material. Englacial and superficial rivers are described, and one of the latter was found to be depositing gravelly material along a line at right angles to the valley down which the ice was flowing.

Certain observations on the rate of movement of the ice-sheet seem to indicate that this is not less than 15 to 20 feet in 24 hours; while the glaciers near the sea-margin appear to be travelling about 25 feet in the same time.

The action of sea-ice is described, and it is inferred that a certain amount of rounding and scratching of shore-rocks, and possibly part of the smoothing of boulders, may be due to this agent.

4. "Additional Notes on the Vertebrate Fauna of the Rock-Fissure at Ightham (Kent)." By E. T. Newton, Esq., F.R.S., F.G.S.

Since the previous paper on the Ightham-fissure fauna published by this Society about five years ago, numerous additional specimens have been obtained, not only by Mr. Lewis Abbott, but also by Mr. Frank Corner and Mr. Kennard.

The present paper gives a very brief account of the new forms which have been discovered and identified during the last five years, with remarks upon some important additional remains of *Mustela robusta*, and of the *Spermophilus* which is now referred to the species *erythrogenoides* of Falconer. This paper adds some 19 new forms to the fauna of the Ightham fissure.

*** The next Meeting of the Society will be held on Wednesday, November 8th, 1899.

CORRESPONDENCE.

ROCK-WEATHERING, SERPENTINIZATION, ETC.

Sir,—Both Mr. Merrill and Mr. Holland deserve the thanks of geologists for their suggestive papers on certain forms of rock change, and the distinction drawn by the former (p. 354, Geol. Mag., August, 1899) between ordinary 'weathering' and more deep-seated changes in rocks is of great importance. The subject is one which my own work has often brought before me, though, as other

questions had prior claims, I have never been able to investigate it systematically. And it is one beset with difficulties, especially when we are dealing with rather old rocks, not the least being that of determining when the alteration for which we have to account, has taken place. But I have always tried, so far as was possible, to call attention to any mineral changes which seemed distinctive, and have sometimes ventured to suggest a cause for them. The subject would well repay any young geologist with sufficient leisure, and on this account, with the same motive as Mr. Merrill, I will venture to offer a few remarks suggested by his paper. As regards 'serpentinization' I have come to the same conclusion as himself, viz., that the change is deep-seated rather than superficial, and that the same is true of certain other hydrous minerals, though it may not hold with some at least of the zeolites. But the anomalies which mineral change presents are apparently considerable. As an example we may select the conversion of augite into hornblende. Sometimes a crystalline grain of the former mineral may pass into one of the latter by a change seemingly no more than paramorphic; sometimes it may break up into a group of smaller grains, not retaining exactly the original outline. Sometimes, carrying this further, it may form one or more elongated crystals (this, as I have pointed out, seems connected with pressure); and sometimes it may be converted into a more or less fibrous and matted mass, in which case not seldom some chemical alteration seems to have taken place. Again, as another anomaly, some light-coloured augites seem very stable, as in certain picrites and granites; while others, as in some hemithrenes, change rather readily into serpentine. But in a mica-trap the augite, probably also not rich in iron, seems to be very unstable, not, however, altering to hornblende. In one dolerite the augite seems to change more readily than the felspar, in another the reverse. Felspar sometimes changes into quartz and white mica, sometimes undergoes other alterations. Here, as in some other cases, much probably depends upon whether the water present is 'stagnant' or in motion. It would be easy to continue the list, but this may suffice to give some idea of the problems presented, and when they have been solved we may proceed to those presented by the devitrification of glassy igneous rocks. Suffice it to say that the changes in a mineral seem to be the outcome of two separate causes; one, its chemical composition; the other, its environment, the principal factors in the latter being water, pressure, and heat. The best way of attacking the problems will be by first studying the simpler cases, viz., those in which we can be reasonably certain that one factor in the environment has so far dominated over the others, that they may be neglected; and then proceeding to the more complicated cases. Of this I think we may be certain, that in nature, with the same materials, similar causes produce identical results, and dissimilar causes the contrary.

T. G. Bonney.